SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JULY 1921.

GENERAL PHYSICS.

1185. *Vector Slide-Rule.* **A. F. Zahm.** (Frank. Inst., J. 191. pp. 525–528, April, 1921.)—The vector slide-rule here described comprises a straight scale, preferably transparent, pivoted on a sheet of cross-section paper, and bearing a small slide like a T-square. A fine line is drawn centrally on the bottom of the scale and passing through the pivot axis; and a like line is drawn on the blade of the T-square. The paper has at least two scales—a circular one about the pivot, and a linear one on a base line through the pivot lengthwise of the sheet. Others can be added to facilitate reading. The method of use is given for finding the magnitude and line of a vector when its components and its moment about a point are known, and various other uses are described. A. W.

1186. *Mechanical Properties of Plastic Bodies.* **H.** and **F. le Chatelier.** (Comptes Rendus, 171. pp. 695–699, Oct. 18, 1920.)—At sufficiently high temperatures, under the influence of forces which are not strong enough to produce work-hardening, glass and steel assume successively three kinds of deformation: (1) an instantaneous elastic strain which disappears at once on the removal of the stress; (2) a sub-permanent deformation, of the same order of magnitude as (1), which is produced slowly under continued stress and disappears equally slowly when the latter is removed; (3) plastic flow produced at a constant rate (unlike (2), which becomes continuously slower) and which is permanent. This rate of flow is proportional to the distorting stress and follows an exponential curve with temperature. The coefficient of instantaneous elasticity falls progressively as the temperature rises, and is at 95° C. about half the value that it has at room temperatures. F. C. T.

1187. *Compressibility of Diamond.* **L. H. Adams.** (Washington Acad. Sci., J. 11. pp. 45–50, Feb. 4, 1921.)—The paper discusses the measurement, by a method previously described [Abs. 510 (1919)], of the compressibility of diamond, using some 30 gm. of diamond chips of various sizes up to 1 or 2 mm. in their largest dimension. Taking the compressibility of the soft-steel containing vessel as $0{\cdot}60 \times 10^{-6}$ per megabar (1 megabar = $0{\cdot}987$ atmo.), that of diamond was found to be $0{\cdot}16 \times 10^{-6}$ megabar, the lowest compressibility of any known substance. From a consideration of formulæ, given by Richards, Einstein, Lindemann, Grüneisen, and Debye, expressing the relations connecting compressibility with other physical properties, it appears that the low compressibility of diamond is intimately related to its high melting-point, its low expansion coefficient, and its high atomic frequency. Very accurate values of Poisson's ratio for the various elements might be obtained from Debye's equation if the compressibility and specific heat were previously determined. G. W. DE T.

1188. *Vibrations of Beams and Whirling of Shafts.* **E. H. Darnley.** (Phil. Mag. 41. pp. 81–96, Jan., 1921.)—After reference to previous work on the subject, the author investigates the equation giving the periods of the transverse vibrations of uniform beams and the whirling speeds of uniform shafts, simply supported at any number of intermediate points, and again when also supported at the ends. New functions, ϕ and ψ, for the solution of the equations obtained, are tabulated and graphed. A general theorem similar to one relating to the critical loading of a strut, which has been recently given by Cowley and Levy [Abs. 890 (1918)], is obtained in cases of symmetrical arrangements of the supports. The question of the distribution of the supports to give the greatest value of the slowest period or whirling speed is discussed; and it is shown that this period or speed is a maximum when the supports are equidistant. G. W. DE T.

1189. *Theory of Elasticity.* **E. Jouguet.** (Comptes Rendus, 172. pp. 311–314, Feb. 7, 1921.)—Poincaré has shown how we can study small deformations of an elastic solid when the initial state is such that the tensions are not zero. The present paper deals with certain thermodynamical properties of elastic solids in such deformations, in particular with Rayleigh's law of reciprocity, specific heats, and the propagation of waves. A. W.

1190. *Model Experiments in Connection with Submarine Warfare.* **G. S. Baker.** (Inst. Naval Architects, Trans. 62. pp. 33–41; Disc., 41, 1920. Engineering, 109. pp. 770–773, June 4, 1920.)

1191. *Fatigue of Steel under Combined Bending and Torsion.* **A. Ono.** (Kyushu Univ., Coll. Eng. Mem. 2. No. 2. pp. 117–142, 1921.)—A mathematical investigation of the failure of carbon steel under combined bending and torsion. The paper also describes a machine made for testing the results obtained mathematically, by means of which it is shown that the endurance of a material under alternating bending appears to be independent, within limits, of the action of a superimposed torsion. J. L. H.

1192. *Effect of Cooling on a Cement Pier.* **E. A. Hodgson.** (Dominion Obs. Ottawa, Publ. 5. pp. 27–44, Jan. 28, 1921.)—The author gives the results of a series of experiments on a cement pier, heated by an electrical heater. When the pier is in equilibrium with the heater on, the current is turned off for two hours and then turned on again. When turned off, there are oscillations in the curve of cooling, with maxima and minima, showing also a lag of an hour after the heater is turned off. When the heater is turned on again, there is an anomalous reverse drift. If the heater is left off, the oscillations continue until equilibrium is reached—several days sometimes. If then the heater is turned on for two hours, there are no oscillations, but the anomalous reverse drift may sometimes occur. The author suggests the possibility of a different result with different piers, and also the possibility of testing all piers in this way. For instance, piers used for longitude work, generally performed in the early night hours, may at that very time be undergoing erratic tilts due to cooling after sunset. He thinks some of the phenomena of microseisms may be affected in a similar way.

The Deformation Instrument.—A full account is given of the instrument employed in the foregoing experiments, with general view, elevation, and plan of the instrument itself and a view of the recording apparatus, and a further description of experiments to determine the scale value of the record, by means of an interferometer with a thermoelectric tilting arrangement. W. W. B.

1193. *Oscillations of Incompressible Gravitating Fluid Ellipsoids.* **P. Appell.** (Comptes Rendus, 171. pp. 761–766, Oct. 26, 1920.)—The author gives a brief bibliography pertaining to Lejeune-Dirichlet's problem of the general movement of incompressible gravitating fluid ellipsoids which remain throughout ellipsoidal, and points out that solutions of this problem, assuming a constant pressure on the surface, can be applied, so far as infinitesimal oscillations are concerned, to the more general problem of Poincaré, the determination of the small movements of the ellipsoidal masses relative to a uniformly rotating system of axes. As exemplifications, the elementary case of a stationary sphere is worked out, and indications are given for applying the method to a MacLaurin or Jacobi ellipsoid. G. W. DE T.

1194. *Ripple Motion.* **J. C. K. Rao.** (Calcutta Math. Soc., Bull. 11. pp. 173–178, Dec., 1920.)—In the endeavour to verify Wilton's theory [Abs. 646 (1915)], the author found that:—For finite amplitudes the crests of waves begin to divide with increase of wave-length, the form of the waves thus becoming complex with two or more crests in each wave-length. The wave-form changes with the depth of liquid, becoming simpler when the depth is very small. The depth at which the change of form occurs decreases with decreasing wave-length—as was to be expected. The waves were excited by Raman's form [Abs. 348 (1920)] of Fleming's motor vibrator, in which the amplitude and the wave-length can be conveniently and accurately varied by varying the speed of the motion by means of a rheostat included in the circuit. The ripples are observed stroboscopically, and then appear as a series of concentric circles at equal distances, in the case of small amplitudes. In the case of large amplitudes, the circles are doubled, tripled, etc., as the wave-lengths are increased, corresponding to two or more crests for each wave-length. Some photographs of these forms are given, and the phenomena observed are discussed mathematically and accounted for. The paper is prefaced by a bibliography of memoirs on the problem of wave motion on the surface of a liquid. G. W. DE T.

1195. *Force-Transformation, Proper Time, and Fresnel's Coefficient.* **F. Slate.** (Phil. Mag. 41. pp. 652–664, April, 1921.)—Newtonian dynamics, and relativity based on a Lorentz transformation are compared in relation to electronic conditions. General methods of analysis are outlined and the inferences broadly stated. The treatment is admittedly empirical and inconclusive, but utility is claimed in indicating that such a widening of Lagrange's plan is of good promise for the further discussion of energy-fluxes in terms of mechanics.

A. B. C. L.

1196. *A Method of Analysis suitable for the Differential Equations of Mathematical Physics.* **W. L. Cowley** and **H. Levy.** (Phil. Mag. 41. pp. 584–607, April, 1921.)—Desirable features of solutions of differential equations applicable to problems of practical importance are discussed. Since the instruments at disposal can at best only attain a certain degree of accuracy, an equally approximate solution, otherwise unrestricted, of the equations is sufficient. But if it is necessary to select a particular member of a class satisfying certain requirements, particular forms of solution, especially particular forms of expansion, are most convenient. The considerations, notably that of throwing the differential equation into the non-dimensional form, are applied to the case of a series of struts, to the differential equation of the steady two-dimensional flow of a viscous fluid, and to the problem of determining the whirling speed of a shaft whose cross-section varies along its length. The equations of the flow of an incompressible viscous fluid—almost unique in mathematical physics in that no single unrestricted and complete solution has yet been obtained in any problem—are made the object of a special study, working on the lines indicated.

A. B. C. L.

1197. *The Physical Significance of the Least Common Multiple.* **N. Campbell, E. C. C. Baly.** (Phil. Mag. 41. pp. 707–716, May, 1921.)—The paper, arising from private discussion between its authors, in which complete agreement is not arrived at, is couched in the form of a criticism and a reply. In his criticism N. Campbell refers to previous work on absorption spectra by E. C. C. Baly [see Abs. 1287 (1920)], in which conclusions are based on the observation that one of the frequencies (or wave-numbers) characteristic of the spectrum is the L.C.M. of other characteristic frequencies, pointing out that the L.C.M., although still taken to mean the least common *integral* multiple, is here applied to fractions. He demonstrates generally, and illustrates by examples, how widely different the computed L.C.M. of two numbers representing physical quantities may be according to the radix of the scale of notation employed for calculation, when possibility of small experimental error is present, and argues that, unless an indivisible unit of frequency in the absorption spectra considered is proved to exist, and the frequencies can be measured with mathematical accuracy, the only alternatives are (1) that the agreements are mere coincidences, (2) that all experimental physics is founded on a delusion and scales of notation have physical importance.

In his reply, E. C. C. Baly admits the main criticism made against the L.C.M. to be obviously sound, but points out that his theory is based on the assumption that each elementary atom is characterised not by a frequency but by its energy quantum, and sees no difficulty in the postulation of a fundamental unit of energy—regarding frequency as being due to the time factor in the process involving the shift of an electron from one stationary orbit to another. He emphasises the large amount of physical observation supporting his view, and suggests that the hesitation to accept the existence of a fundamental atomic quantum of energy, possibly that associated with the atom of hydrogen, must surely give way before the experimental evidence now adduced. A. B. C. L.

1198. *Motion and Hyperdimensions.* **F. Tavani.** (Phil. Mag. 41. pp. 647–651, April, 1921.)—The paper is written to establish a general relation showing how hyperdimensions are brought into evidence by carrying out an analytical operation which is susceptible of dynamical interpretation, and to derive therefrom, for the particular case of three dimensions, a characteristic which can be extended to spaces of any dimension. The development is entirely mathematical and cannot be usefully abstracted. A. B. C. L.

1199. *Queries respecting Relativity Theories.* **E. Gehrcke.** (Zeits. techn. Physik, 1. 6. p. 123, 1920.)—The author poses the following queries. Is not Poincaré justified in his argument [La Science et l'Hypothèse] that any possible experimental result is expressible in terms of Euclidean geometry as against those relativists who maintain the contrary? If the bending of a light ray grazing the sun's surface cannot be accounted for by refraction by the sun's gaseous envelope, may it not be that the sun's gravitation field slightly reduces the speed of light either by an increase in the density or a decrease in the elasticity of the adjacent ether? If the shift of spectral lines towards the red be confirmed, may it not also be the consequence of the effect of the sun's gravitation field on the adjacent ether? The author also calls attention to the fact that the formula given by Gerber in 1898 gives the same value as Einstein's for the Mercurial anomaly provided the sun's gravitation [gravitational potential] be transmitted with the speed of light. In conclusion, he observes that if it be considered rash to base inferences as to the nature of the ether upon minute, barely discernible phenomena, it is equally rash to erect the relativity theory upon the same foundations. G. W. DE T.

1200. *Einstein's Gravitational Theory.* **G. W. Walker, A. S. Eddington.** (Nature, 107. pp. 169–170, April 7, 1921.)—Anderson has pointed out that, to obtain from Schwartzschild's equation, $ds^2 = -\gamma^{-1}\delta r^2 - r^2\delta\theta^2 - r^2\sin^2\theta\delta\phi^2 + \gamma\delta t^2 \ldots$ (1) an expression independent of direction for the gravitational deflection of light, it is necessary to make the substitution $r = (2r_1 + m)^2/4r_1$, which gives

$$ds^2 = (2r_1 + m)^4/(2r_1)^4 \cdot \{\delta r_1^2 + r_1^2\delta\theta^2 + r_1^2\sin^2\theta\delta\phi^2\} + (2r_1 - m)^2\delta t^2/(2r_1 + m)^2 \ldots (2),$$

and for the velocity of light $(2r_1 - m)(2r_1)^2/(2r_1 + m)^3$, r_1 being now regarded as the radius vector. The transformation cannot alter the apsidal progress determined by Einstein from (1). The gravitational potentials in (2) are not additive, and Eddington [Report p. 59] proposes there to neglect squares of m/r_1, which would make them so. But the resulting equation gives an apsidal progress 4/3 the amount given by (1). Squares of *m* cannot, therefore, be neglected at an early stage without violating the observations which (1) or (2) was called in to explain. The adjustment is, in fact, so delicate in (1) that we may not approximate at all until the end of the calculation. What then, the author asks, are the exact equations for two finite bodies, both mobile ?

A. S. Eddington (*ibid.*, p. 170).—Eddington admits Walker's argument in the above case, but believes that the neglect of squares in the calculation of the $G_{\mu\nu}$ for continuous matter on p. 59 of his "Report" was justified, but the argument being intricate, he would welcome criticism. With respect to Walker's concluding query he remarks that the problem of two bodies in Einstein's theory is an outstanding challenge, like the problem of three bodies in Newton's theory. The solution will give ds^2 *throughout all time*, and therefore incidentally the tracks of the particles which are the singularities of the solution. He is not satisfied that it has yet been proved that the tracks are periodic—that there is no dissipation of energy by the gravitational waves set up. G. W. de T.

1201. *Relativity Symposium.* **A. Einstein.** (Nature, 106. pp. 781–813, Feb. 17, 1921.)—The author summarises the development of the relativity theory from its origin in the idea of Faraday and Maxwell which dominates it, the continuity of physical processes, and consequently their expressibility by partial differential equations. Maxwell effected this for electromagnetic processes in bodies at rest by the conception of the magnetic effect of the vacuum-displacement-current, with the postulate of the essential identity of electrostatic and electrodynamic-induction fields. Hertz's attempted extension of electrodynamics to moving bodies, involving the ascription of a definite velocity at every point to the ether, was in contradiction to Fizeau's fundamental experiment on light transmission through moving liquids. Lorentz accounted for the known facts on the theory of a static ether intrinsically independent of matter; but this appeared to prefer the one system of coordinates at rest relatively to the ether, in opposition to Newtonian dynamics. All experience in electrodynamics —particularly Michelson's experiment—favoured the equivalence of all inertial systems, *i.e.*, the special principle of relativity. Searching analysis of the physical significance of space and time showed the Galilean (Newtonian) transformation to involve arbitrary assumptions, in particular that simultaneity possesses a meaning independent of the motion of the coordinate system. But Maxwell's field equations for vacuum were found to satisfy special relativity when the Lorentz transformation was employed, so that the equations of physics, as far as electrodynamically expressible, were unaltered in form by transition from one inertia system to another. Mathematically, all such systems of equations were covariant with respect to the Lorentz transformation. Thus the special principle, like that of Carnot, supplies a general condition which all natural laws must satisfy. Later, Minkowski found a particularly elegant and suggestive expression for this condition of covariance, one which reveals a formal relationship between three-dimensional Euclidean geometry and the space-time continuum of physics, from which it follows that, in respect of its rôle in the equations of physics, though not with regard to its physical significance, time is equivalent to the space coordinates (apart from the relations of reality), so that physics may be regarded as statics in a four-dimensional Euclidean continuum. The two main stages of special relativity were (1) the adaptation of the space-time metrics to Maxwell's electrodynamics, and (2) an adaptation of the rest of physics to that altered space-time metrics. (1) yields the relativity of simultaneity, the influence of motion on measuring rods and clocks, a modification of kinematics, and in particular a new theorem of velocity addition; (2) supplies a modification of Newton's law of motion for large velocities and information of fundamental importance on the nature of inertial mass. Inertia was found to be a general property of energy, not confined to matter. If a body receives energy E, the inertial mass increases by E/c^2, where c is the velocity of light *in vacuo*, while a body of mass m is to be regarded as a store of energy mc^2. It was found impossible to link up gravitation with special relativity in a natural manner, and the author was struck by its being fundamentally distinguished from electromagnetic forces by the fact that all bodies fall with the same acceleration in a gravitational field, *i.e.*, the gravitational and inertial masses of a body are numerically identical. Might they not be identical? This question led directly to the general theory of relativity, the author asking himself further whether the earth might not be regarded as free from rotation if the centrifugal force acting on all bodies at rest relative to the earth could be conceived as being a real field of gravitation, or part of such a field? Gravitation and inertia would then become identical. Newton's law of field would not admit of such interpretation. But might it not be replaced by one that fits in with the field which holds with respect to a rotating system of coordinates? Account would have to be taken of the fact that ponderable masses, that is to say, the energy density—a magnitude having the transformational character of a tensor—would be the determining factor in producing the field. Considerations based on the metrical results of special relativity led to the conclusion that Euclidean metrics would be applicable to small domains only of fields specified by accelerated systems of coordinates. But this was sufficient to ensure the magnitude ds of the special theory retaining its significance, while the coordinates degenerated into numbers of no physical significance, their sole purpose being the numbering of the space-time points—as Gaussian coordinates in the theory of surfaces. As a consequence of this, ds would be representable in the form $ds^2 = \sum_{\mu\nu} g_{\mu\nu} dx_\mu dx_\nu$, $g_{\mu\nu}$ being functions of the space-time coordinates. Moreover, the nature of the space-time variation of the $g_{\mu\nu}$ would determine both the space-time metrics and the gravitational field governing the mechanical behaviour of material points. The law of the gravitational field was determined mainly by the conditions: (1) It must be valid for an arbitrary coordinate system; (2) it must be determined by the energy tensor of matter; (3) it must contain no higher differential coefficients of the $g_{\mu\nu}$ than the second, and must be linear in these. The law so obtained, although fundamentally different from Newton's, corresponded to it so closely in the deductions derivable from it that but very few criteria were to be found on which the theory could be decisively tested by experiment. Outstanding problems awaiting solution are: Do electrical and gravitational fields differ so greatly in character as to be incapable of expression in terms of a common formal unit? Do gravitational fields play a part in the constitution of matter, and is the continuum within the atomic nucleus to be regarded as appreciably non-Euclidean? Is inertia to be traced to mutual action with distant masses? And connected with the latter: Is the spacial extent of the universe finite? The author, with Mach, believes the answer to be necessarily affirmative, and looks for a solution in the dynamical investigation of the large systems of fixed stars from the point of view of the validity of the Newtonian law of gravitation for immense regions of space.

E. Cunningham.—The fact that the relativity theory leaves the problem of absolute motion and absolute rotation exactly where Newton left it is insisted upon, and it is recalled that in 1853 Riemann wrote that "the ground of the measure relations existing in the universe, if continuous, must consist in the binding forces acting upon it." This statement really implies the whole relativity doctrine, asserting, as it does, that the measure relations of phenomena are incapable of determination on any absolute scale, independent of the phenomena themselves.

F. Dyson.—The observational methods by which the bending of light rays near the sun was measured during the 1919 solar eclipse and found to agree with Einstein's gravitational theory are described and some of the alternative solutions proposed and disproved are discussed.

A. C. D. Crommelin.—Some of the alternative hypotheses proposed as capable of accounting for the Mercurial anomaly are critically discussed, and the fact that Einstein's expression $3v^2/c^2$, where v is the speed of the planet and c is that of light, for the angular motion of the apse (in fractions of a circumference) per revolution of the planet, involves no empirical or arbitrary constant. It is also pointed out that, according to the most recent observations, the excess of Venus's apsidal motion over the amount given by Einstein's theory is well within the limits of observational error.

C. E. St. John.—Mathematical physicists are at present not agreed as to the validity of Einstein's deduction from his theory of a displacement of the absorption lines in the solar spectrum relative to terrestrial sources. The observational results differ from Einstein's prediction in at least four important ways. The observed displacements are not proportional to the wave-length; they differ from element to element in the same spectral region; for the same element and spectral region they vary with line-intensity; the displacements show both large positive and negative divergences from the calculated results. Evershed adduces his observations upon the spectrum of Venus as evidence of an "earth-effect" driving the gases from the earth-facing hemisphere of the sun, and would, by their hypothetical action, explain the observed displacements of the solar lines, and thus negative the deduction from Einstein's theory. For statistical discussion the quantity of data available is as yet quite inadequate even in the case of Fe, the most widely studied element.

J. H. Jeans.—The relativity theory of gravitation, although vigorous and striking, is but one of the branches of a firmly established parent tree. The latter, is expressible in the form that all the phenomena of nature are the same for any two observers who move relative to one another with a constant velocity. This is known to be true as regards the mechanical forces considered in Newton's laws, and merely generalises Newton's corollary V: *The motions of bodies included in a given space are the same among themselves, whether that space is at rest, or moves uniformly forward in a right line without any circular motion.* Thus no experiment on board ship can disclose a ship's uniform velocity through the sea. But drop the lead into the sea, and a circular ripple will spread out, and the velocity with which the point of entry advances from the centre of the circle will give the velocity of the ship through the sea. The Michelson-Morley experiment should have given indications of a corresponding ripple in the ether due to the earth's orbital motion, and Majorana's recent experiment, somewhat less refined, should have enabled us to watch the progress of the ripple directly. From these and other experiments the result invariably emerges that the wave-front appears to be a sphere having the observer at its centre. The null result of the experiments so refined as to be capable of revealing a hundredth part of the actual orbital velocity compels the inference that the last of our optical models, the electromagnetic ether, must either be amended or abandoned, and the indications are strong that the less drastic course will not suffice. But new laws of Nature are discovered, not only by means of mechanical models, but by tentative generalisations of known laws, controlled by experiment. Now what Einstein calls the special relativity principle—the parent tree—thus firmly established, is inconsistent with the exact truth of Newton's gravitational law. Thus it predicts that a freely moving planet cannot describe a perfect ellipse about the sun as focus. But before actual orbit can be predicted, or any other positive gravitational prediction can be made, additional hypotheses must be introduced. Such is Einstein's gravitational theory. Whether this and other branches have been placed on the trunk with complete accuracy is admittedly still an open question—it must of necessity remain so until the difficult questions associated with the gravitational shift of spectral lines have been finally settled—but the main trunk of the tree can be disturbed by nothing short of a direct experimental determination of the absolute velocity of the earth, and the only means which can possibly remain available for such a determination now are gravitational.

H. A. Lorentz.—It is shown by a simple analysis which appears to be, as the author himself considers, unimpeachable, that if we adopt Fresnel's theory of a stationary ether, supposing also that a material system can have a uniform translation with constant velocity without changing its dimensions, we must surely expect the result predicted by Maxwell. Hence follows the physical reality of the Fitzgerald-Lorentz contraction. The question then arises as to how far the dimensions of a solid body will be changed when its parts have unequal velocities, when, *e.g.*, it rotates about a fixed axis. The problem then becomes one for the ordinary theory of elasticity, provided only this be first adapted to the relativity principle. It is made clear that this is feasible, even in the gravitational or "general" theory, and the requisite formulæ are here developed. The author mentions also that he has worked it out for the case of a thin circular disc rotating with constant speed about a central axis, perpendicular to its plane. The disc is taken to be ideally "rigid," *i.e.*, a body for which the two elastic moduli are infinite. The centrifugal force will then have no effect on the dimensions, but the changes required by the theory of relativity will subsist. The result is that, if v be the velocity at the rim, the radius will be shortened in the ratio of $1 : 1 - v^2/8c^2$. The circumference changing to the same extent, its decrease is seen to be exactly one-fourth of that of a rod moving with the same velocity in the direction of its length. The case is comparable to that of a hot metal band fitted tightly on a wheel and then left to cool, so that the smaller contraction was to be expected.

O. J. Lodge.—The author's argument may be briefly summarised as a vigorous protest against the tendency of some relativists to regard the theory as a philosophy of Nature destined to displace the Newtonian step-by-step method of developing physical theory *in toto*, and replace it by systems of relativistic differential equations which, as they increase in comprehensiveness, approach asymptotically towards complete emptiness of physical content. The Michelson-Morley experiment does not even prove that the velocity of light is always the same in all directions, and the existence of such an absolute constant in nature remains simply an hypothesis. Relativity theory has already proved its value as a guide to investigators, but its guidance is not positive but negative; like entropy and least action, it may be termed a blindfold method of investigation. To make a philosophic scheme of existence complete, more than the expression of a static instant is required: there must be duration likewise. Time has to be associated with space, and this can be done only by means of a velocity factor of some kind; but relativists have sought it, not in the intrinsic speed of the ether turbulence—which is really the fundamental velocity in existence—they have utilised the more obvious consequence of this fundamental speed, viz., the uniform velocity with which the ether can convey a great variety of signals. What is required is a supplement to Newtonian mechanics expressed in terms of the medium which he suspected and sought in vain, and introducing the additional facts—especially that of variable inertia—since discovered. Such a philosophy would insist on the specific state of the medium throughout a gravitational field being the absolute essence of the existence of each material particle; their separate potentials being combined additively. Equally an electric field must be constitutively inseparable from the electron, though the compounding of electric fields need not be simply additive. That the particle is a singularity in the medium, and that its inertia and gravitational field are essential to, and part of, its existence, must certainly be true, a fact which Einstein has grasped. Nature is a unity in which all non-mental phenomena must find expression in terms of one definite quiescent medium, full of exceedingly fine-grained turbulent energy.

H. Weyl.—The author is one of those who regard Einstein's general relativity theory as a step in representing all the phenomena of the universe as an outcome of its geometry. He remarks that modern physics renders it probable that the only fundamental forces in Nature are those which have their origin in gravitation and in the electromagnetic field, and he here attempts to describe in general terms the manner in which he has attempted to extend Einstein's gravitation theory so that it may include electromagnetic phenomena. He considers its great achievement to be that it has brought the obvious principle of the relativity of motion into harmony with the existence of inertial forces. The Galilean (or Newtonian) law of inertia shows the existence of a kind of obligatory guidance in the universe, which constrains a body left to itself to move with a perfectly definite motion, once it has been set in motion. At every position P in the universe this guiding field determines the infinitesimal parallel displacement of vectors from P to infinitely near points. This *affine connection*, as he calls it, of a continuum (the difference between straight and curved) is in the Newtonian system given by its geometrical structure and not limited to infinitesimal displacements. With Einstein, however, the guiding field is a physical reality dependent on the state of matter, and manifests itself only infinitesimally. The immense success of Einstein's theory is rooted in the fact that the effects of gravitation also belong to the guiding field, as was to be anticipated from the equality of gravitational and inertial mass. The planets follow exactly the orbits destined to them by the guiding field; there is no special gravitational force necessary, as in Newton's theory, to cause deviation from their Galilean orbits. He accuses Einstein of inconsistency in assuming the integrability, as he calls it, of infinitesimal parallel displacements. In other words, he objects to assuming the constancy of the interval *ds* between two events, and generalises Riemann's procedure by replacing *ds* on a certain defined world-line by ϕds, where ϕ is an arbitrary positive multiplier varying in any manner from point to point along the world-line. Then, just as Riemann found an adequate method of measuring the interval between two adjacent events by means of the quantities $g_{\mu\nu}$ and the quadratic form, so Weyl has found a sufficient means of attaining his purpose by means of four arbitrary functions $\phi\mu$ and a linear form. Now the gravitation phenomena were easily obtainable from the Galilean principle, according to which the world-direction of a mass point in motion follows at every instant the parallel displacement. But a charged mass point does not so follow the guiding field, and Weyl has obtained the correct equations only by the hypothetical statement of a definite and concrete law of Nature, which is possible within the framework of the theory, but is not a necessary consequence of its general principles. It was then found that when the metrical connection alone was virtually varied, the most simple of the assumptions possible led exactly to Maxwell's equations. Thus, whereas Einstein's gravitation theory gave certain inappreciable deviations from the Newtonian theory, such as could be tested experimentally, the author's interpretation of electricity—he is almost tempted to say unfortunately—results in the complete confirmation of Maxwell's laws. If Maxwell's magnitude of action be supplemented by the simplest additional term which also allows of the variation of the relation of action, Einstein's laws of the gravitational field are obtained, with, however, two small deviations: (1) That cosmological term appears which Einstein added later to his equations, and which involves a universe of finite extent. A hypothesis conceived *ad hoc* by Einstein to explain the generally prevailing equilibrium of masses results here of necessity. Whereas Einstein has to assume a pre-established harmony between the cosmological constant which is characteristic of his modified law of gravitation, and the total mass fortuitously present in the universe, in the author's theory, where no such constant occurs, the world-mass determines the curvature of the universe in virtue of the laws of equilibrium. Only in this manner, he claims, is Einstein's cosmology at all possible from a physical point of view. (2) In the presence of an electromagnetic field, Einstein's cosmological term must be supplemented by an additional term of similar character. This renders the existence of charged material particles possible without requiring an immense mass-horizon as in Einstein's cosmology.

Several other contributions of interest cannot be dealt with from want of space. An extensive bibliography of books and pamphlets is appended. G. W. de T.

1202. *Alternative View of Relativity.* **F. Slate.** (Phil. Mag. 41, pp. 96–106, Jan., 1921.)—In earlier papers [Abs. 967 (1920) and 208 (1921)] the *modus operandi* characteristic of relativity has been found working in disguised agreement with the results of Newton's equations when variable inertia is included in the latter, and the older problems of motion resisted proportionally to (speed)^2, when expressed in a form inspired by the prospect of making it a model for electrons has been the main key in the reconciling discussion. This problem allows the normalisation of aspects, especially of vital energy relations, which formerly seemed exceptional. Consider the equation of rectilinear motion [equation 8 of second paper] and its recasting in terms of terminal velocity, v_1, viz.,

$$(a)\ \mathrm{P} - \mathrm{R} = m_1\dot{v}\ ;\ (b)\ \mathrm{P} = m_1 v_1^2 \dot{v}/(v_1^2 - v^2)\ ,\ [\mathrm{R} \equiv m_1 k v^2].$$

In (*b*) occurs directly the factor whose different powers occur in all relativity calculations, and fruitful is its linking of an A.M and an H.M.

$$\tfrac{1}{2}\,[v_1/(v_1 + v) + v_1/(v_1 - v)] = v_1/(v_1 + v)\ .\ v_1/(v_1 - v) = v_1^2/(v_1^2 - v^2)$$

the first member involving the root idea of Einstein's substitutions; while the equality connects sums and products, or quantities and their logs., which control the mathematics at many points. It is then not surprising that relativity and the author's argument should agree in building P and the equation of motion into the foundations. Einstein's velocities secure for P invariance in form and magnitude throughout the frame-group U, so long as their derivatives based on a common variable are expressed [Note 2 to equation (25), in second paper]. Only at the transition to "local time" are the reduction factors combined with this invariant nucleus. The task for physics is to trace the simpler elements plainly indicated through the shifting patterns of a kaleidoscopic algebra. The motion equation implies a gross energy flux due to P, partly diverted from the kinetic energy of M, by passive resistances summed in R. Complete diversion and conversion is entertainable as a limit. The mass m_1, weight-mass, and constant in (*a*), is replaced as a factor of the same acceleration by a variable effective inertia in (*b*), a mathematical step not modifying the physics. The transformation essentially involves a terminal velocity, and so is invalid outside the range $(0, v_1)$. Imaginary combinations beyond these limits argue nothing against greater speeds attainable under other physical conditions. And this holds specifically for a light-speed, c, if entering as a terminal velocity. For an interval taken conveniently between rest and any speed, v, the equation of work in the standard frame, F, leads through (*b*) to $\mathrm{W} = m_1^2 v_1^2/2\ .\ \log\,(\mathrm{P}/m_1\dot{v}) = m_1^2 v_1^2/2\ .\ \log\,(z\mathrm{P}/z m_1 \dot{v})$. Any dimensions and magnitude are allowable for z, and m_1 may be any constant inertia and P any propelling force, provided the conditions preserve the same terminal speed. Again,

$$\int_0^v \mathrm{P}v\,dt = m_1 v^2/2 + \left[- m_1 v^2/2 + m_1 v_1^2/2\ .\ \log\left\{v_1^2/(v_1^2 - v^2)\right\}\right],$$

showing the same cancellation of explicit kinetic energy operating as in the work equation for Lorentz's "deformable electron," so that circumstance does not *by itself* require electronic inertia to be wholly electromagnetic. An equation is then obtained formally parallel with results adopted for this electron and enlarged for legitimate frames in relativity, corroborating one basic proposition of the author's treatment, and also opening the question, how far m is a physical quantity. Further results move towards making broadly representative what was devised specially for the Lorentz electron. An additional suggestion from the algebra associated with terminal speed is to utilise a kinetic estimate of future action as potential energy, according to the conditions, for intervals beginning at rest and at v, preparing the way for a possible consolidation with electrostatic potential energy. Abraham's electron proves to conform to the author's train of ideas, though as a whole they are not made explicit by it. The algebraic link established with this electron is confirmed by simple verifications, in the course of which it appears that the kinetic energy of any "weight-mass," m_1, must be rated mechanical, and the author suggests that the current doctrine that the inertia of the Lorentz electron is wholly electromagnetic may be insecure—at least if the author's equation of motion be made fundamental. Various uncertainties are indicated which must continue until new evidence decides them, one pertinent inquiry concerning itself with the quantity $\gamma(v)$, whose integral powers figure so prominently. Is this series naturally commensurate with intervals that the physics determines?

G. W. de T.

1203. *Relativity.* **F. W. Lanchester.** (Engineering, 111. pp. 477–479, April 22, and pp. 514–516, April 29, 1921.)—One of the most troublesome and unconvincing pieces of physical machinery introduced into the discussion of relativity by Einstein is the thing which is called a "clock." According to the theory rigid bodies, and indeed distances, alter their lengths, and the masses of bodies are alleged to change as a function of velocity. A "clock" under these conditions conveys no clear and definite meaning. To gloss this over, or take it for granted, is really to beg the whole question. Minkowski has shown that time can be treated mathematically as a fourth dimension; but in order that the four-dimensional space should be Euclidean the time values must be multiplied by $\sqrt{(-1)}$, and in the paper a simple case is treated geometrically with this in view. Three axes are chosen: t (not $\sqrt{(-1)}t$) being measured vertically downwards; x, the direction of relative motion of two systems, to the right; and z, one of the two remaining space directions, vertically upwards from the plane of the paper. One of the two systems is regarded as being at rest. At any instant the particles in the system will be represented by points in a plane parallel to the xz plane of reference, or on the paper by points on a horizontal line moving vertically downwards with the flow of time. As the vertical ordinate represents t and not $\sqrt{(-1)}t$ the space xzt and the plane xt are not Euclidean. At the time and place represented by the origin O a luminous detonation takes place, and the spherical expanding wave is represented by a horizontal circle, expanding as it moves downward with uniform velocity, and tracing out a cone, the axis of which is coincident with the t axis, and which is represented on the paper by two straight lines sloping equally right and left through the origin.

The paper then shows that to represent a system moving with a small velocity with respect to the first, a plane must be taken slightly inclined to the xz plane. This plane x_1z moves parallel to itself, and in it, too, the velocity of light is the same in all directions. The result is deduced that two events that are simultaneous on one system are not simultaneous if considered as happening in a system in motion relatively to it. Events taking place in the line where the xz and the x_1z planes intersect are simultaneous, while all events in the xz plane are simultaneous for an observer in that plane, and the same is true for an observer in the x_1z plane for events in the moving system. The planes xz and x_1z are designated planes instanta of the two systems. The difference in time between events in the two planes instanta increases with the distance from the line of intersection, being measured by the distance between the two intersecting planes at each point. It should be noted that the intersection of the x_1z plane with the cone mentioned above is an ellipse, which at first sight seems to imply that the velocity of light is not the same in all directions in the moving system. It must be remembered, however, that the space xzt is non-Euclidean, and it is found that when the problem is introduced into Euclidean space, by using $\sqrt{(-1)}t$ instead of t, the ellipse becomes a circle.

The author deduces that if an observer in the xz system has a 1-metre bar with which he measures another 1-metre bar in the x_1z system, the length of which is in the x direction, he will find its length to be less than 1 m. An observer in the x_1z system will find the length of the bar in the xz system less than 1 m.

In order to deal with velocities which are large compared with the velocity of light, the velocity of the moving system is supposed to increase step by step, by equal increments Δv from zero. The second increment, however, is measured not along the x axis, but in the direction of x_1, and a further tilting takes place to x_2. The same goes on for further increments, and new axes or planes instanta are obtained x_3, x_4, etc. These, if the increments are infinitesimal, are all tangent to the hyperbola obtained by cutting the cone of light by the plane $z = ct$, where c is the velocity of light. The result is that the increase can be carried on indefinitely, without reaching a limit, and velocity increment can be added to velocity increment indefinitely without reaching the velocity of light. Incidentally the continued addition of velocity increments, if combined with motion along the t axis, is by way of constituting an accelerated system, or according to Einstein a gravitational field. It appears also that the so-called increase of mass that it is found necessary to postulate in modern electromagnetic theory is a paradoxical way of expressing the fact that a velocity cannot be integrated by summing its components. The integration of a velocity within any given system is less that due to its real components. A computation has been made by graphic methods of the *apparent* increase of mass due to increase of velocity on the basis of the present theory; the graph obtained is slightly higher than either J. J. Thomson's calculations or Kaufmann's determinations, though it agrees more nearly with the latter. H. N. A.

1204. *Comprehensive Exposition of the Principles of the Theory of General Relativity.* **G. A. Maggi.** (N. Cimento, 21. pp. 5–33, Jan., 1921.)—The author's paper is intended to act as a stimulus to others to undertake the study of the relativity problem. L. H. W.

1205. *An Outline of the Application of the Theory of Space Groups to the Study of the Structure of Crystals.* **R. W. G. Wyckoff.** (Am. J. Sci. 1. pp. 127–137, Feb., 1921.)—The theory of space groups defines all the ways of symmetrically arranging points in space; it thus supplies the basis upon which an entirely general method for the study of crystal structure can be built. Such a method has been used by Nishikawa in studying spinel [see Abs. 1679 (1915)] and also by the present writer [see Abs. 1532 (1920)]: it has now reached a degree of completeness such as to be generally applicable to the problem of determining complicated structures of crystals. The present paper is an attempt to present only those details which are required in order that the results of this theory may be immediately applicable to the determination of crystal structure. Previous work is referred to on the connection between space groups and the structure of crystals as deduced from their effects upon X-rays. The great advantage in using space groups lies in the fact that if in a particular case the number of molecules associated with the unit of structure and the symmetry are known, all of the possible atomic arrangements can be written down and considered in the light of further X-ray measurements. It can then be told, with a given amount of experimental data, whether the particular structure under examination can or cannot be uniquely defined. The geometrical theory of space groups is developed in the paper at some length, point groups, space lattices, and space groups being illustrated by simple examples. The relations between space groups and crystals are then discussed, and those modifications in the results of the theory of space groups that are required in order to serve as the basis for a general method for the study of the structure of crystals are indicated. H. H. Ho.

1206. *Crystal Structure of Magnesium Oxide.* **R. W. G. Wyckoff.** (Am. J. Sci. 1. pp. 138–152, Feb., 1921.)—Previous measurements on powdered magnesium oxide have led to the conclusion that this compound has the same crystal structure as sodium chloride. Such a study did not, however, furnish a unique solution. The following determination, using Laue photographs and X-ray spectrum measurements, is based upon the general method for studying crystal structure which has developed from the theory of space groups [see preceding Abstract]. In the case of a cubic crystal, there is no uncertainty as to the choice of those coordinate axes which will give the simplest unit of structure. The number of chemical molecules associated with the unit cube of magnesium oxide was found, in the usual manner, from the density and a spectrum measurement from a principal face. If magnesium oxide possesses holohedral symmetry, then the only simple structure possible is the sodium chloride arrangement. Certain cases of grouping, showing tetartohedral symmetry and more complicated holohedral arrangements each with 32 molecules associated with the unit, are in agreement with the existing experiments. These other possibilities, however, differ but slightly from the sodium chloride arrangement, and cannot be positively treated by the experimental facilities now available. A discussion of the nature of the forces between the atoms of magnesium oxide concludes the paper. H. H. Ho.

1207. *Normal Orbit of the Electron in the Atom of Mercury.* **A. Terenin.** (Nature, 107. p. 203, April 14, 1921.)—Researches on ionisation and resonance potentials of mercury vapour, and on its ultraviolet absorption in a non-luminous state, together with considerations from the serial type of the mercury spectrum, lead to the conclusion that in the absence of exciting agencies the spectral electron remains on the orbit 1S, the normal orbit of the atom of mercury. On the other hand, R. Dearle has found a strong infra-red absorption band at λ10140, and this suggests the possibility of a second normal orbit in the mercury atom, namely, the orbit 2P. The corresponding ionisation and resonance potentials, however, have never been observed. Experiments carried out by the author with non-luminous mercury vapour, using a photographic method which enabled λ11300 to be reached, showed complete absence of a marked absorption at λ10140, although the pressure of the mercury vapour reached 1 atmo. There is thus no necessity for assuming a second normal orbit for mercury. A. W.

1208. *Dimensions of Atoms and Molecules; Distance between Atomic Centres of HI Molecule.* **W. L. Bragg** and **H. Bell.** (Nature, 107. p. 107, March 24, 1921.)—Certain relations which are to be traced between the distances separating atoms in a crystal make it possible to estimate the distance between their centres when linked together in chemical combination. Similar evidence can be obtained from viscosity measurements [see Rankine, Abs. 1109 (1921) in the case of gaseous elements]. Both crystal and viscosity measurements indicate that (*a*) the elements at the end of any one period in the periodic table are very nearly identical as regards the diameters of their outer electron shell, and (*b*) in passing from one period to the next there is a definite increase in the dimensions of the outer electron shell, the absolute amount of this increase estimated from viscosity measurements agreeing closely with that determined from crystal measurements. A further check on these observations is afforded by the infra-red absorption spectra of HF, HCl, and HBr.

The evidence indicates a distance of $1 \cdot 61 \times 10^{-8}$ cm. between the atomic centres of the HI molecule. A. B. W.

1209. *Electro-Crystalline Properties as Conditioned by Atomic Lattices.* **J. Larmor.** (Roy. Soc., Proc. 99. pp. 1–10, April 6, 1921.)—The method of analysis of crystal lattices by means of X-rays, introduced and applied by W. H. and W. L. Bragg, has led to the view that the ultimate crystalline element is the atom (or a group of atoms—the "ion") and not the chemical molecule: so that each atom, presumably with its ionic electric charge, often stands in identically the same relation to a number of surrounding atoms of the other kind with opposite charge, and therefore cannot be associated physically with any one of them. The alternative view was to regard the chemical molecule as the crystalline unit: its associated positive and negative atomic ions might then form an electric diad with definite polar moment orientated in a definite direction—and with this the new schemes come into contrast.

In the discussion following the author compares these two fundamentally different conceptions. In addition to the results obtained by X-ray analysis, reasons are given which favour the view that the atomic mode of crystalline structure is probably the correct one. A. B. W.

1210. *Isotopes: their Number and Classification.* **W. D. Harkins.** (Nature, 107. pp. 202–203, April 14, 1921.)—On the basis of his theory of nuclear building, the author shows that it is to be expected that the number of isotopes should be considerably greater for elements of even than for those of odd atomic number. Aston's experimental observations are now given in support of this deduction. The author, further, discusses the reasons for the predilection of atoms for the number 2, or for even numbers. A. B. W.

1211. *Constitution of the Hydrogen Atom.* **F. H. Loring.** (Chem. News, 121. pp. 315–318, Dec. 31, 1920.)—The author summarises this paper as follows:—" Hydrogen appears to be unique in not being a whole-number atom. The fractional part of its mass is relatively great. Hydrogen does not find a proper place at the heads of Groups I and VII. Its chemical activity is evidently such as not to enable it to form stable polymerides answering to known elements. There is a gap at the end of Group I that does not accommodate any radio-active element. Similarly there are gaps below manganese which seem difficult to fill, and one of these would have to be filled by a radio-active element, which seems improbable. On the hypothesis that all elements are polymerides of hydrogen, a difficulty arises owing to the fractional value, suggesting that the fundamental unit has a mass of 1 exactly. Considering hydrogen as a complex atom composed of mass parts $a = 1\cdot0000$, $b = 0\cdot0077$, and c (an electron) $= 0\cdot00055$, a and b could possibly be more properly placed at the heads of Groups I and VII respectively, and thus account for the very strong affinity between these parts, and thereby explain the stability of the hydrogen complex (ab), whilst the respective parts alone might have very great affinity, especially a which could polymerise and form the whole-number elements as revealed by Aston's recent experiments. Moreover, constructing a modified Langmuir periodic table, the absence of elements in Groups I and VII would suggest a shortage of elementary material, so to speak; but this shortage would be made up at the heads of these groups by introducing the entities a and b at these places. This procedure reveals a numerical regularity. . . . It is also suggested that such a fractional entity as b might be attached to other elements in small multiples and thus help to account for certain chemical irregularities in the periodic table. The fact that ordinary hydrogen is not known to polymerise tc form the elements would be expected if it carries an auxiliary part which deprives it of this property." A. B. W.

1212. *Atomic Structure.* **N. Bohr.** (Nature, 107. pp. 104–107, March 24, 1921.)—The author refers to a paper by N. Campbell [Abs. 209 (1921)] in which is discussed the problem of the possible consistency of the assumptions about the motions and arrangement of electrons in the atom underlying the interpretation of the series spectra of the elements based on the application of the quantum theory of atomic structure, and the apparently widely different assumptions which have been introduced in various recent attempts to develop a theory of atomic constitutions capable of accounting for other physical and chemical properties of the elements. N. Campbell puts forward the interesting suggestion that the apparent inconsistency may not be real, but rather appears as a consequence of the formal character of the principles of the quantum theory, which might involve that the pictures of the different phenomena may have a totally different aspect, and nevertheless refer to the same reality. In this connection he directs attention to the so-called " principle of correspondence," by the establishment of which it has been possible —notwithstanding the fundamental difference between the ordinary theory of electromagnetic radiation and the ideas of the quantum theory—

to complete certain deductions based on the quantum theory by other deductions based on the classical theory of radiation.

The author discusses this "principle of correspondence" and shows how it establishes an intimate connection between the character of the motion in the stationary states of an atomic system and the possibility of a transition between two of these states, and therefore offers a basis for a theoretical examination of the process which may be expected to take place during the formation and re-organisation of the atom. A picture of such a process not only leads to a detailed insight into the structure of spectra, but also suggests a definite arrangement of the electrons in the atom, of a type which seems suitable to interpret the high-frequency spectra and the chemical properties of the elements.

The author promises soon to publish a fuller account which shall deal in greater detail with the questions here discussed. A. B. W.

1213. *Constitution of Lithium.* **F. W. Aston and G. P. Thomson.** (Nature, 106. pp. 827–828, Feb. 24, 1921.)—Positive rays of the alkali metals were first obtained by Gehrcke and Reichenheim by using as anode a heated metal strip upon which a suitable salt was melted. This method, improved in technical detail, has now been applied with J. J. Thomson's "parabola" analysis to determine the atomic weights of the isotopes of lithium. The experimental observations leave no doubt that lithium is a complex element of isotopes of atomic weights 6 and 7.
A. B. W.

1214. *Constitution of Alkali Metals.* **F. W. Aston.** (Nature, 107. p. 72, March 17, 1921.)—Refers to previous paper [preceding Abs.]. The mass-spectrograph has now been applied by the author to the investigation of the atomic weights of the heavier alkali metals. The following results are given :—

Sodium (at. wt. 23·00) gives a single line only at 23, indicating that it is a "pure" element. This line has been used as a standard for the following.

Potassium (at. wt. 39·10) gives a strong line at 39 and a very weak companion at 41. This element therefore probably consists of two isotopes, 39 and 41.

Rubidium (at. wt. 85·45) gives two lines of relative intensity about 3 to 1, at 85 and 87, corresponding to two isotopes of rubidium.

The mass spectra obtained from caesium (at. wt. 132·81) have so far only one line which indicates a mass 133; if another isotope exists it is present in proportions of less than 5 %. A. B. W.

1215. *Utility of Sunshine Records.* **K. Knoch.** (Meteorolog. Zeits. 38. pp. 11–18, Jan., 1921.)—The question is asked: Can we, with present-day sunshine records, undertake to study the distribution of sunshine duration over a given region? After a critical study, it is concluded that with long series of records the errors introduced by the instruments are substantially reduced, and do not influence the means to such an extent as was perhaps thought formerly. Errors of 0·1 to 0·2 hour per day are, however, always likely. More irregular is the error introduced by the use of series extending over different periods, and, though reduced to the same period, isohyets can only be drawn to show the broad climatic features and, for monthly averages of daily sunshine, not for intervals smaller than one hour.

Some improvement is thought possible in the existing instruments, but one entirely free from objection cannot be expected. More accurate records could usefully be obtained from a few selected points by means of the apparatus developed by Maurer, but this could not be brought into general use. Experimental research is necessary in order to determine what improvement is possible. M. A. G.

1216. *Rate of Ascent of Pilot Balloons.* **B. J. Sherry.** (Monthly Weather Rev. 43. pp. 692–694, Dec., 1920.)—The rate of ascent of pilot balloons, determined during 165 ascents by observation with two theodolites, are compared with the rate indicated by the United States Signal Corps formula for ascent in still air, $V = K\,(l/L^{2/3})^{5/8}$, in which l is the free lift and L the total lift of the balloon, which formula is in turn compared with those of Dines, Rouch, and Hergesell. It is found that: (1) under all weather conditions the formula rate is exceeded in the lower atmospheric layers, (2) balloons ascend faster during strong winds than under other conditions, (3) they also ascend faster during that part of the day when convection is strongest, (4) the rate is relatively slow when winds are light, (5) a sudden change may take place in the rate of ascent due to the passage of the balloon out of one current of air into another. Above 1000 m. the rate of ascent is much more uniform and in better agreement with the formula, but it is emphasised that it is not safe to give too much weight to any individual one-theodolite ascent. It is suggested that for single theodolite work balloons of standard weight and standard formula rate should be employed and a percentage correction applied. For example, in the United States the Signal Corps rate would be increased by 20 % in the first minute, 10 % for the second and third, and 5 % for the fourth and fifth minutes. Experience would probably suggest individual series of corrections for each station. M. A. G.

1217. *New Researches on the Rainfall of Germany.* II. *Snowfall.* **G. Hellmann.** (Preuss. Akad. Wiss. Berlin, Ber. 11. pp. 246–257, 1921.)—Snow-days, defined as those on which the fall of snow or sleet is equivalent to at least 0·1 mm. of rain, increase in frequency, in the lowlands of N. Germany, from between 20 and 30 per year in the west to more than 60 in the east, and lines of equal frequency (isochions) follow closely the course of the January isotherms, the 30-day isochion corresponding to the 0° C. isotherm. Elsewhere, the isochions tend to follow the contours, the frequency exceeding 60 days per year on the high land. Level for level the frequency is higher for places near mountain systems than for places more remote. A map of isochions is reproduced. The monthly distribution of snow frequency from Oct. to May is given in tabular form for representative stations, and the greatest frequency is seen to fall in Jan., Feb., or March according to geographical position. The relation of snow-days to days of snow-cover is considered. In N. Germany the ratio decreases from 1·6 in the east to unity along the 30-day isochion, west of which snow-days are in excess. Elsewhere, the ratio of days of snow-cover to snow-days exceeds unity on the high land, ranging from 1·4 to 1·7. M. A. G.

1218. *The Daily Temperature Curve.* **L. Becker.** (Roy. Soc. Edinburgh, Proc. 40. 1. pp. 89–96 and 40. 2. pp. 97–101, 1919–1920.)—

It has been suggested that the mean daily temperature curve may be represented by the differential equation $\ddot{\tau} + a\dot{\tau} + b(\tau - c_0) = \mathrm{F}(z)$ where τ is the temperature and z the zenith distance of the sun. This is based on physical considerations and its derivation is given. The main object of the paper is to show how the constants a, b and the function $\mathrm{F}(z)$ may be determined from the numerical values of $\ddot{\tau}$, $\dot{\tau}$, and τ given by the thermograph records and how the value of c_0 and the constants of integration c_1 and c_2 may be obtained from the integral of the differential equation. This is done for the twelve curves, one for each month, for Glasgow, based on 45-year records, 1868–1912. The comparison of the coefficients so obtained, for different places, would yield valuable information as to climate and is thought more promising than a comparison of Fourier coefficients. While sufficiently accurate for this, the differential equation does not, however, quite represent the actual case. M. A. G.

1219. *Relation of Telescopic Definition to Cold Waves.* **W. H. Pickering.** (Monthly Weather Rev. 48. p. 511, Sept., 1920.)—Telescopic definition or "seeing" is recorded at Mandeville, Jamaica, nearly every night when it is clear, on a scale of 12, and is at its worst there during the winter months, when the circulation of the temperate zone may affect that island. In the temperate latitudes a high barometer and cold wave are most injurious; in the tropics the vicinity of a hurricane. During Jan., Feb., and March 1920, there were at Jamaica seven periods of bad seeing, five followed by cold periods as indicated by the records of minimum temperatures. These were the only cold periods, and it appears that about three days' warning of such can often be obtained by the occurrence of bad seeing. A "high" over Florida and Georgia usually followed the low minima at Jamaica, nearly a week after the period of bad seeing. M. A. G.

1220. *Relation between the Nightly Outgoing Heat Radiation and the Amount and Kind of Clouds.* **S. Asklöf.** (Monthly Weather Rev. 49. pp. 93–94, Feb., 1921.)—Ångström has given the relations $\mathrm{R}_m = (1 - km)\mathrm{R}_o$, and $\mathrm{R}_o = \mathrm{T}^4/293^4 . (\mathrm{A} + \mathrm{B} \times 10^{-\gamma p})$, where R_m is the effective outgoing radiation, R_o the actual outward radiation with a cloudless sky, T the absolute temperature, and p the vapour pressure; m is a measure of the cloudiness, $\mathrm{A} = 0{\cdot}439$, $\mathrm{B} = -0{\cdot}159$, $\gamma = 0{\cdot}069$, and $k = 0{\cdot}09$. The present author, who has made measurements at Upsala during the months March–June 1918, gives $\mathrm{A} = 0{\cdot}126$, $\mathrm{B} = 0{\cdot}179$, and, for lower clouds only, $k = 0{\cdot}083$. m must take account of the thickness as well as the kind of clouds and is difficult to estimate at night. It is suggested that a measure of cloud density, better than the observed, may be obtained by inserting in the first of the above formulæ the observed value of R_m and the value of R_0 computed from the second equation. M. A. G.

1221. *Temperature Variations in the Lowest Four Kilometres.* **C. K. M. Douglas.** (Roy. Meteorolog. Soc., J. 47. pp. 23–43; Disc., 43–46, Jan., 1921.)—A brief account of the conclusions arrived at in this paper has already appeared [see Abs. 1541 (1920)]. The main contention is that "the temperature variations which are nearly always in progress are largely the result of the passage over the place of observation of different supplies of air whose temperature was determined by a number of factors operating for several days previously" and "that the upper-air temperature depends to a considerable extent on the origin of the upper current." In support, the author draws upon experience gained while flying almost daily in N.E. France, when a large number of observations of upper-air temperature and humidity were obtained at sufficiently small intervals to allow the variations in the upper-air temperature to be studied in relation to the sequence of changes revealed by the synoptic charts of surface conditions, while the data are also treated statistically.

The paper further discusses and emphasises the relationship between weather changes and variations in the upper-air temperature, and support is found for the theories of V. Bjerknes in this connection. Much light is thrown on the structure of the atmosphere in a number of cases of typical surface pressure distribution.

To be reconciled with the main conclusion of this paper is the intimate relationship between temperature and pressure in the upper air revealed by the high positive correlation coefficients of **W. H. Dines,** who, in the *discussion,* opposes the view that the source of air supply predominates in determining its temperature. The **Author,** however, contends that his view is not disproved by the statistical results. M. A. G.

1222. *Cloud Nomenclature.* **C. F. Brooks.** (Monthly Weather Rev. 48. pp. 513–519, Sept., 1920. Paper read before the Am. Meteorolog. Soc., April, 1920.)—The author considers the difficult problem of providing a practicable method of recording clouds, which will give more precision and greater detail than the present International Classification. Any system, to be of practical use, must be based on *appearance* from the ground, and must include form, coarseness, and density. Recognising only seven types of form, three degrees of coarseness and five of density, a cloud record was kept for 50 days, but, while being complete, was found inconvenient on account of time absorbed in observing and the difficulty of comparing results and of selecting nomenclature to differentiate the possible combinations (about 3000). The ten forms of the International Classification are accordingly reviewed in detail and modifications of the definitions suggested, in particular to provide stricter differentiation between such pairs as cirro-cumulus and alto-cumulus, cirro-stratus and alto-stratus, nimbus and other rain clouds. This enables a tabular guide to be provided to assist in the identification of types. To secure greater detail it is suggested that 14 letters be employed, in addition, to indicate certain characteristics, for instance, *f* (ragged), *s* (smooth), *n* (rain or snow falling from cloud, whether or not precipitation reaches ground). Thus St^f would represent fracto-stratus and A.St.^{sn}, smooth alto-stratus from which rain or snow is falling, and so on. M. A. G.

1223. *Climatological Factors Governing the Selection of Air Routes and Flying Fields.* **C. L. Meisinger.** (Monthly Weather Rev. 48. pp. 525–527, Sept., 1920.)—In the preliminary work of planning an aerial route for continued use, or deciding on the position of an aerodrome, a knowledge of the average weather conditions over the proposed route, or in the locality of the proposed flying field, is of prime importance. The principal factors to be considered in the case of a route are:—(1) Wind speed and direction, (2) frequency of low clouds and fog, (3) frequency and intensity of thunderstorms, (4) vertical temperature distribution

and its diurnal changes. In the case of an aerodrome the average precipitation may be added. The individual bearing of each factor is discussed in the article. A further article will deal with time- and fuel-saving modifications of an air route, introduced by current weather conditions.
M. A. G.

1224. *Unusual Pilot Balloon Trajectory.* **G. A. Clarke.** (Roy. Meteorolog. Soc., J. 47. pp. 117–120; Disc., 120–121, April, 1921.)—A single-theodolite balloon ascent to a height of about 2 km. at Aberdeen at 16h. 30m. on June 30, 1920, showed, when worked up on the usual assumption of a uniform rate of ascent, horizontal velocities constant in direction but ranging from + 117 miles/hr. (W.S.W.) to —114 (E.N.E.), the mean being about 25 miles/hr. (W.S.W.). Such velocities are extremely improbable and reasons are given for supposing in fact that there was very little vertical variation of wind speed and direction. Making this assumption, the variations in the rate of ascent of the balloon are readily obtained and the magnitude of the responsible vertical air currents is deduced. From the second to the sixth minute inclusive the balloon appears to have encountered a downward current reaching 5 miles/hr., while from the seventh to the tenth it was in an upward current reaching 7 miles/hr. During the remaining four minutes of the ascent no appreciable vertical air movement was experienced. Independent evidence of considerable vertical air motion on this occasion was furnished by the peculiar form of the smoke trail from a neighbouring tall chimney, and by the observed very turbulent condition of fracto-cumulus cloud. W.S.W. winds are notoriously squally at Aberdeen.

In the *discussion*, **J. S. Dines** compared these results with determinations of vertical currents during two-theodolite ascents at Pyrton Hill 1910–13, from which it appears that the downward current in the present instance was of somewhat exceptional intensity. Rising currents greater than the present had, however, been encountered in the first half-km. layer, 4 times in 66 summer ascents and he had observed one of 11 miles/hr.
M. A. G.

1225. *Problems Relating to Rotating Fluid in the Atmosphere.* **G. Green.** (Phil. Mag. 41. pp. 665–675, April, and p. 200, July, 1921.)—Some cases of rotating fluid in an isothermal atmosphere are shown to be consistent with the hydrodynamical equations and to satisfy the equation of continuity to a certain degree of approximation. The extension to an atmosphere in any other physical condition with, however, no horizontal temperature gradient, is easily made. Vertical movement is supposed absent or negligible. Rotation in horizontal circles round a fixed axis, with uniform angular velocity ω throughout, is possible if the axis is inclined polewards from the vertical at an angle i given by $\tan i = 2\Omega \cos \phi/(\omega + 2\Omega \sin \phi)$, where Ω is the earth's angular velocity, and ϕ the latitude of the centre of isobars at the surface. ω is positive for cyclonic and negative for anticyclonic rotation, and in the latter case ω cannot exceed $2\Omega \sin \phi$, so that its max. possible value for anticyclonic rotation is zero at the equator and 2Ω at the poles.

If such rotating systems are given a small velocity of translation the equations are still approximately satisfied if the inclination of the axis is suitably adjusted, but the motion would soon become modified. A case, however, is found in which an east or west translation with unrestricted speed is possible, but the paths of the fluid relative to the axis must be ellipses which only become circles in the case of a westward movement with twice the speed of a point on the earth's surface in the same latitude. M. A. G.

1226. *Use of Artificial Horizons at Sea.* **H. N. Russell.** (Roy. Astron. Soc., M.N. 81. pp. 417–420, March, 1921.)—The desirability of devising some method by which altitudes can be observed at sea with the sextant, when the heavenly bodies are visible but the horizon is concealed by fog, haze, or darkness, has led to a great number of attempts to devise an artificial horizon which may be attached to the sextant itself, or otherwise employed on board ship. Almost all of these devices are practicable on land, while some are very convenient; and a number have been successfully used in aircraft. But it appears to be the general opinion of mariners that no such apparatus has yet proved satisfactory for use at sea. Tests carried out by the author on board the *Carmania*, with a sextant provided with a bubble telescope, confirmed this opinion. Even with a very moderate roll only very rough readings could be made, the discrepancies between successive settings amounting to one or two degrees. This trouble is due to the deflection of the apparent direction of gravity, relative to the observer, by the acceleration towards or from the azimuth of the sun, arising from the motion of the ship. A possible solution of the difficulty is the development of some device for indicating the vertical, with a long period of swing—probably not less than two minutes. Such an apparatus, if properly damped, would be little affected by the relatively short-period disturbances due to rolling and pitching. A suitable type of gyroscopic pendulum, mounted in gimbals, and carrying above it a plane mirror, might be very useful. A. W.

1227. *Exceptionally High Solar Prominence, Oct. 8, 1920.* **O. J. Lee.** (Astrophys. J. 53. pp. 310–316, May, 1921.)—*Solar prominence of Oct. 8, 1920.*—Fifty-seven photographs were obtained, covering the various stages of the growth and gradual breaking up and final disappearance of this prominence, which attained the record height of 831,000 km. The changes are described in detail with the help of 7 photographs and 6 plots. The superstructure rose slowly at first until coherence with the base was partly broken, when the velocity suddenly changed to a much higher value, which was maintained until a more complete break was accompanied by another sudden increase. The motion of other parts was quite complex, some material returning to the sun, while other parts seemed to be attracted to points outside the sun. Electrostatic forces may have been acting, but it is not understood how. The prominence was associated with no sun-spot and seemed to be a new eruption. The H line of calcium was used in making the spectroheliograms. AUTHOR.

1228. *Dissymmetry in Sun-spots.* **S. Chevalier.** (Observat. Zô-Sè, Ann. vol. 11. 1916, review by A. L. Cortie in Observatory, 44. pp. 121–122, April, 1921.)—Measures of eight years' plates obtained at Zô-Sè 1909–17, were employed to test the dissymmetry of the solar spots with regard to the central meridian, and also the Wilsonian effect and the depths of the spot-centres. The author concludes that the east limb is not more spotted than the west limb. He would also regard any apparent dissymmetry as due to the instrument or method employed, and not to the sun. His measures of penumbra favour Wilson's theory on the whole, but there is not only wider penumbra on the limb side of spots in 88 % of the cases, but also a tendency for penumbra to be wider on the east side of spots.

In regard to depth of spots below the photospheric level, a range is found up to 3000 km., the general depth being one-fourth of this. This is decidedly less than Young's value.

All the spots considered were isolated spots with complete penumbra, and it seems to be established that these in general become shallower.
W. W. B.

1229. *Advance of Perihelion of a Planet.* **A. Anderson.** (Phil. Mag. 40. p. 670, Nov., 1920.)—The author thanks Pearson for indicating [Abs. 1563 (1920)] an error in his paper [Abs. 1049 (1920)], and modifying his procedure, obtains the correct amount for the advance of Mercury's perihelion in accordance with Einstein's theory. G. W. DE T.

1230. *Striking Prominence.* **J. Evershed.** (Kodaikanal Obs. Bull. 55. Observatory, 44. p. 98, March, 1921.—Abstract.)—A remarkable eruptive prominence [see Abs. 1206 (1920)] was observed in 1916 May 26. A high column shot up rapidly to a height of half-million miles above the sun, accompanied by falling streamers. The eruptive velocity, as usual, showed acceleration, reaching a maximum of 457 km. per sec. After an hour the upper part of the column became detached and faded away rapidly. W. W. B.

1231. *The Oblateness of Saturn.* **P. Stroobant.** (Comptes Rendus, 172. pp. 913–915, April 11, 1921.)—The author obtains four values for the "aplatissement" of Saturn:—

From motion of node of Mimas ...	0·1023
From motion of node of Tethys ...	0·1027
From motion of node of Rhea	0·1037
From motion of perisaturn of Titan	0·1021
Mean	0·1027 = 1/9·74,

a value which he considers far more accurate than any obtained by direct observation. He concludes in the course of his investigation that the effect of the rings is negligible, and their mass exceedingly small.
W. W. B.

1232. *Pons-Winnecke Comet and its Meteor Shower.* **W. F. Denning.** (Nature, 107. pp. 15–16, March 3, 1921.)—The author sketches the history of the comet, draws attention to the meteor shower that followed its last return in 1916, and suggests the probability of an even more striking display this year. He enumerates five of the periodic comets similarly associated with meteor showers. W. W. B.

1233. *Problems of Cosmogony.* **W. D. MacMillan.** (Observatory, 44. pp. 92–94, March, 1921.)—This is the reviewer's rejoinder to the reply of the author [J. H. Jeans, Abs. 379 (1921)] to his original criticism. He admits the incorrectness of his own figures, but considers that the author has erred in the other direction. His main contention is that the assumption that gravitation is the only source of energy leads to dynamical impossibilities, so that the contraction hypothesis is a complete failure; and he claims that gravitation must be regarded as relatively unimportant, and fresh advances only to be sought in increased knowledge of the origin and dissolution of the atoms. W. W. B.

1234. *Measurement of the Diameter of α Orionis with the Interferometer.* **A. A. Michelson** and **F. G. Pease.** (Mt. Wilson Observat. Contrib. No. 203. Astrophys, J. 53. pp. 249–259, May, 1921.)—*Twenty-foot Interferometer for Measuring Minute Angles.*—Since pencils of rays at least 10 ft. apart must be used to measure the diameters of even the largest stars, and because the interferometer results obtained with the 100-in. reflector were so encouraging, the construction of a 20-ft. interferometer was undertaken. A very rigid beam made of structural steel was mounted on the end of the Cassegrain cage, and four 6-in. mirrors were mounted on it so as to reduce the separation of the pencils to 45 in. and enable them to be brought to accurate coincidence by the telescope. The methods of making the fine adjustments necessary are described, including the use of two thin wedges of glass to vary continuously the equivalent air-path of one pencil. Sharp fringes were obtained with this instrument in Aug. 1920.

Diameter of α Orionis.—Although the interferometer was not yet provided with means for continuously altering the distance between the pencils used, some observations were made on this star, which was known to be very large. On Dec. 13, 1920, with very good seeing, no fringes could be found when the separation of the pencils was 121 in., although tests on other stars showed the instrument to be in perfect adjustment. This separation for minimum visibility gives the angular diameter as $0''\cdot047$ within 10 %, assuming the disc of the star uniformly luminous. Hence, taking the parallax as $0''\cdot018$, the linear diam. comes out 240×10^6 miles.

Interferometer Method of Determining the Distribution of Luminosity on a Stellar Disc.—The variation of intensity of the interference fringes with the separation of the two pencils depends not only on the angular diam. of the disc but also on the distribution of luminosity. The theory is developed for the case in which $I = I_0(R^2 - r^2)^n$, and formulæ are given for determining n from observations.

A Table of Values of $\int[1, 0](1 - x^2)^{n+\frac{1}{2}} \cos kx \; dx$, for n equal to 0, ½, 1, and 2, and for k up to 600°, is given. AUTHORS.

1235. *Interstellar Clouds of Metallic Gases.* **F. Henroteau.** (Roy. Astron. Soc., Canada, J. 15. pp. 62–70, Feb., pp. 109–119, March, 1921.) —The author discusses first the researches of others into the question of clouds of meteoric dust or gas in space, arising from the phenomenon of stationary H and K lines of Ca, and of D_1 and D_2 of Na. He takes as a concrete example a photograph of the region of the "North America" nebula near α Cygni, and considers its probable dimensions, obtaining a possible greatest length of some 750 million million km. He recalls that π^5 Orionis shows two K lines, one certainly stellar, and mentions other early B stars of special behaviour in this part of the spectrum. In some early B stars the K line is not quite stationary, but has a small motion in the same period as the greater one shown by the other lines; this may be due to a sort of blending. He combats the suggestion that all the Ca-cloud is moving with the star, and proceeds to a detailed

study of the radial velocity variations of σ Cygni, in which he finds the H_ϵ line indicating quite different motion from that of the other H lines, its light-curve being 6 days later. He suggests an explanation of this, promising fuller examination in Publications of Detroit Observatory.
W. W. B.

1236. *New Variable Star in Perseus.* **A. S. Williams.** (Roy. Astron. Soc., M.N. 81. pp. 392–397, March, 1921.)—Though noted as variable fifteen years ago by the author, this star, B.D. + 44°·994, does not seem to have been recognised as such, in the absence of elements. In 1920 the author made 263 observations on 67 nights in order to discover the nature and period of variation, with the inclusion of a single observation in 1918. The result is not very satisfactory. The brightness increases rapidly from 9·37 M. near minimum to 8·8 M. at maximum in 55 minutes and declines almost as quickly to 9·2 M. The curve about maximum resembles the extreme type of Cepheid variable, but no simple regular uniform period will fit the observed maxima. The author recommends spectroscopic study of the star, to throw light on the difficulty. W. W. B.

1237. *Spectrum of Nova Geminorum II.* **F. J. M. Stratton.** (Solar Physics Obs. Cambridge, Annal. 4. pp. 1–71, Dec., 1920.)—This is the complete work of which an abstract has already been given. [See Abs. 1057 (1920).]
W. W. B.

1238. *Stellar Magnitudes and their Determination.* **H. S. Jones.** (Nature, 107. pp. 142–146, March 31; 173–176, April 7, and pp. 205–207, April 14, 1921.)—This is a monograph dealing fully with the history of stellar photometry, magnitude scales, comparison of photometric catalogues, visual and photographic magnitudes, methods of observation (such as the diffraction grating used at Greenwich outside the object glass), star-counts to different magnitudes, colour index and spectral class, intrinsic luminosity, or absolute magnitude, with summary of the results of recent work of H. N. Russell and H. Shapley. W. W. B.

1239. *Comparison of Trigonometrical with Spectroscopic Parallaxes.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 81. pp. 354–356, March, 1921.)—The author examines a volume of 260 trigonometrical parallaxes determined photographically at the Leander McCormick observatory. 194 of the stars have had spectroscopic parallaxes determined at Mt. Wilson. Arranging these in order of magnitude of the spectroscopic parallax he finds the excess of spectroscopic over trigonometrical parallax, increases from zero to a maximum of 0″·013 for parallaxes of 0″·06. In the absence of closer scrutiny of errors in adopted apparent magnitudes, in relative intensities of spectrum lines used for fitting absolute magnitude, and in the empirical curves used for the same purpose, the author is reluctant to correct the spectroscopic values, and prefers to attribute the discordances to the trigonometrical ones. W. W. B.

1240. *Double-Star Orbits from Incomplete Data, with Application to μ^2 Boötis.* **G. C. Comstock.** (Astron. J. 33. pp. 139–145, April 16, 1921.)—The author thinks that the objection to computing orbits when only a small arc has been described may be overcome in many cases, if instead of simply drawing a curve by estimation through groups of points representing observations, the apparent orbit can be made an ellipse,

V.2
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controlled throughout by all the data. He sets forth several theorems connecting various elements of the true and projected orbits; and applies his tests to the observations of μ^2 Boötis, obtaining for it elements in fair agreement with those of See and Jackson. W. W. B.

1241. *Two Nebulæ with very Large Velocities.* (Lowell Observat. Circ. Observatory. 44. p. 129, April, 1921.)—Two small spiral nebulæ, N.G.C. 584 and 936, show very large velocities away from the sun. The first is a small nebula with bright nucleus, and for its spectrogram an exposure of 28 hours, which took a fortnight to complete, was necessary. The radial velocity indicated was 1800 km. per sec. The other nebula has a large bright nucleus with extensions surrounded by an oval disc of nebulosity, very faint and structureless, requiring 34 hours' exposure. Its deduced radial velocity is 1300 km. per sec. Both spectra are approximately of solar type. W. W. B.

1242. *The Real Motion of the Stars.* **G. Forbes.** (Roy. Astron. Soc., M.N. 81. pp. 357–360, March, 1921.)—The author is trying to find the most fruitful method of making use of Voûte's catalogue of radial velocities of 2071 stars, mostly with Boss' proper motions and 423 of them having parallax determined. He takes into account the large proper motions in order to diminish the diffuseness of the area of apices, which scatter over 160° of longitude, on account of the uncertainty of the parallax. He then proposes to avoid stars of large proper motion and of small parallax, or choose only those stars whose parallax error cannot displace the apex more than 5°. For this purpose he suggests computing two apices for each star, using the least and greatest possible values of the parallax, and rejecting every star for which the two apices differ by more than 10°, the correction for solar motion being left until afterwards.

He finds that the stars of high radial velocity do not, as might be expected, show specially small perpendicular velocities: in fact, the two sets are nearly equal for stars with radial velocity greater than 90 km. per sec.

He tabulates his results for the stars of radial velocity exceeding 40 km. per sec., and gives a diagram of apices for stars of the highest and intermediate classes of radial velocity. W. W. B.

1243. *Constitution and Formation of Spiral Nebulæ.* **A. Véronnet.** (Comptes Rendus, 172. pp. 957–959, April 18, 1921.)—The author is continuing a previous discussion [see Abs. 1026 (1921)], and suggests that a binary, whose components are big enough and close enough, may develop into a spiral nebula. The friction of the two bodies revolving in contact will supply enough energy to produce a centre of intense radiation, whose pressure overcomes gravity and drives off the particles of the stars in opposite directions in the line joining the centres, and thus produces a spiral nebula.

He calculates that a surface temperature ten times greater than that of the sun would cause an initial velocity of the order of 100,000 km. per sec. W. W. B.

1244. *Present State of Double-Star Astronomy.* **J. Jackson.** (Observatory, 44. pp. 80–90, March, 1921.)—After a sketch of the early pioneer work on the subject the author turns to the question of deciding which pairs are physically connected. He says: (1) The probability is much against two stars, as bright as 9th magnitude being within 5″ of each other. (2) Wide pairs showing appreciable relative motion are probably optical. (3) If the relative motion of a pair of stars is definitely less than one-tenth of their proper motion the pair is probably a real binary.

For his present purpose he ignores wide pairs showing no relative motion, though these may be physically connected. He then gives examples from the first 500 stars in Burnham's General Catalogue, of the application of these principles, postponing the doubtful cases; he generalises as follows. (1) In nearly all physical systems for which motion may be expected in a century the separation does not exceed 2″. A few exceptions may be allowed for very bright stars and stars with large parallax or proper motion. (2) If a double star with a separation over 10″ shows relative motion of the components in a century, the probability is that the system is optical (exceptions as above). (3) If the separation is between 2″ and 10″, the system is probably physical and will show no relative motion in a century; but if relative motion is shown, then the nature of this motion, the brightness of the stars, the parallax, and the proper motion must all be considered in forming a judgment as to its inclusion as a binary. Proportionally to the result of his analysis of the first 500 stars he would expect in the whole catalogue 485 physical systems in relative motion, 510 optical systems in relative motion, and 153 systems, probably optical, in relative motion, or, allowing for the stars to be added on account of work done in the 15 years since the publication of Burnham's catalogue, say 700 physical systems in which relative motion has been observed. He compares his estimation with Burnham's own analysis of the catalogue. He next considers the possibility of determining mass and density, and notes how few visual binaries have reliable orbits determined. The average mass of visual binaries appears to be twice that of the sun; so that the usual assumption of mass is justifiable, and it is shown that widely different sets of elements will often make very little difference to the value of $\sqrt[3]{(a^3/P^2)}$, when P is the period and a the semi-major axis in arc. It is possible therefore to make use of binaries when only a small part of the orbit has been described. It is theoretically possible to test doubtful binaries by means of the parallax, and the author applies this to the doubtful stars in the first 500, of which consideration was postponed. He concludes with a table showing the expectation of relative motion for close pairs or pairs with large parallax. W. W. B.

1245. *Enhanced Lines of N in Spectra of Novæ.* **W. H. Wright.** (Roy. Astron. Soc., M.N. 81. pp. 412–414, March, 1921.)—In continuation of the previous discussion the author accepts most of Fowler's suggestions [Abs. 831 (1921)] and concludes that the nebular stage of the spectra of some of the novæ is marked by the presence of the enhanced spectrum of N, and probably also by a number of lines of ordinary N spectrum, both sets of bands conforming to the normal structure. The "4640" stage is produced by the development of enchanced N-radiations into broad nebulous bands, the ordinary N-lines being unaltered, while there is almost complete extinction of enhanced He, 4686, and 3445. The "4640" stage also, he says recurs at intervals after the nebular stage has become established, these recurrences being associated with marked fluctuations of brightness of the star. W. W. B.

LIGHT.

1246. *Variation of Gaseous Refraction with Pressures below one Atmosphere.* **V. Posejpal.** (J. de Physique et le Radium, 2. pp. 85–92, March, 1921.)—A Jamin interferential refractometer was employed in conjunction with a spectrophotometer, and the light used was that of the green mercury line. The gases dealt with were dry air and CO_2 and the pressures ranged from 60 to 700 mm. Results were obtained in good agreement with those of Chappuis and Rivière, and of Rentschler [Abs. 439 (1909)]. Curves are given showing the variation of $(n - 1)/\rho$ with the pressure. It appears that this function is sensibly constant for CO_2 for pressures above 700 mm. and for air for pressures above 2000 mm. Below these pressures, however, both curves fall considerably. A. W.

1247. *Prism Systems.* **G. Gouy.** (Comptes Rendus, 172. pp. 305–308, Feb. 7, 1921.)—A continuation of previous work [Abs. 1051 (1921)]; the present paper dealing with the case where the refracting and reflecting surfaces are all perpendicular to a single plane. A. W.

1248. *Molecular Theory of Refraction, Reflection, and Scattering.* **W. Bothe.** (Ann. d. Physik, 64. 8. pp. 693–712, April 29, 1921.)—A mathematical paper dealing with refraction, reflection, etc., from the molecular standpoint. [See Abs. 696 (1921).] A. W.

1249. *Centres of Absorption of Coloured Solutions.* **E. Adinolfi.** (Accad. Lincei, Atti. 29. pp. 38–41, July, 1920.)—The photographs are obtained with Wratten and Wainwright panchromatic plates. From the examination of a long series of negatives obtained with diverse initial concentrations the following points have been established:—The absorption spectra of potassium and calcium permanganates show eight centres of absorption. The third centre, the wave-length corresponding to which is 5255 Å., has the maximum intensity. Within the limits examined there is absolute identity in the absorption spectra of these two permanganates, in the number and position of the centres of absorption, and in the position of the maximum. A. E. G.

1250. *A Quantum Theory of Vision.* **J. Joly.** (Phil. Mag. 41. pp. 289–304, Feb., 1921.)—The author assumes the origin of luminous and colour vision to lie in the liberation of electrons under light-stimulus within a photoelectric substance existing in the retina, *e.g.*, rhodopsin. Photochemical and photoelectric processes are probably fundamentally alike. As a result of consideration of various researches the author assumes that the velocity acquired when a quantum of energy is imparted to it by visible light is of the order of 10^{-7} cm. per sec. The retina is sensitive to approximately 5×10^{-12} erg, and the quantum for green light is 4×10^{-12} erg. It appears, therefore, that one quantum will suffice to excite vision., *i.e.*, the liberation of a single electron by green or blue light will excite visual sensation. The author then proceeds to discuss the theory in the light of the functions of the rods and cones and the rhodopsin. Quantitative sensitivity is ascribed to the rods, qualitative sensitivity to the cones; the sensitiser is located within the nerve in the one case and without the nerve in the other. After-image phenomena can also be explained by analogy with the electronic theory of photography. The theory supposes the nerve to discriminate between the quanta of three or more representative spectral centres. No interpretation of colour in terms of frequency seems possible, in view of the very high order of frequency that would have to be conveyed to the brain. J. S. D.

1251. *Dioptrics of the Eye.* **A. Ames, Jr.,** and **C. A. Proctor.** (Optical Soc. of America, J. 5. pp. 22–84, Jan., 1921.)—The paper summarises a very comprehensive series of experiments undertaken in order to determine the exact nature of the image received by the eye. A detailed study of spherical aberration, chromatic aberration, oblique astigmatism, and distortion is made, results being presented by the aid of numerous diagrams. A photographic lens embodying the results of investigation of these various factors is being constructed, and it is believed that in connection with the three-colour process a substantial reproduction of the retinal picture can be obtained. It is also suggested that a fuller knowledge of the subject may be of value in suggesting how the various parts of a picture should be painted in order to give a technically pleasing and artistic effect. J. S. D.

1252. *A Statistical Survey of Colour Vision.* **R. A. Houstoun** and **M. A. Dunlop.** (Phil. Mag. 41. pp. 186–200, Feb., 1921.)—The author has previously summarised results of a test on 79 observers by an apparatus resembling the Edridge Green colour-perception spectrometer [Abs. 183 (1918)]. Frequency curves based on these data were prepared, the object being to find whether colour-blind cases were merely "outliers of a homogeneous population" or independent populations of their own. In the former case the curve would be smooth, in the latter there would be a defined secondary peak: the second alternative is required by the Young-Helmholtz and Hering theories. It was found that normal colour vision has sufficient scatter to include colour-blindness as an outlying portion of itself, but that a greater number of observers was needed to disprove the existence of separate maxima for dichromats and monochromats. The present investigation is based on tests of 1000 students, and a different experimental method was adopted, involving the observation of black and coloured discs on a white ground through a microscope. After black dots have been focused the microscope is put out of focus and screwed down until the position of the coloured spots can just be detected. Results were checked to some extent by Edridge Green's bead test. The data are again assembled in diagrammatic form, which with a sufficient number of observers should lead to a smooth curve, corresponding with frequency curves for which K. Pearson has furnished formulæ. Rejecting 14 observers, all the distributions may be regarded as homogeneous, as variations about a mean; but a difference in kind between the colour-blindness of the rejected observers and the colour-blindness of those on the outlying portion of the main curve seems to be indicated. According to Hering's theory the 14 rejected cases must be deficient in the red-green process; on the Young-Helmholtz theory they lack the red sensation. But 14 out of 835 is a smaller percentage that the theories require and the distribution of the 14 does not suggest a well-defined class. J. S. D.

1253. *Reaction of the Eye to Light; Energy required to Produce Visual Sensation.* **P. Reeves.** (Optical Soc., Trans. 22. pp. 1–14, 1920–1921.)—The eye is commonly regarded as analogous to a camera and photographic plate, but there are distinctions. The eye functions over a range of 10^{10} : 1 and is the widest ranged instrument known. The working range of the best photographic plates is much less; a comparison is presented in diagrammatic form. Moreover visual sensation depends largely on intensity of stimulus, while photographic effect is a function of exposure.

Visual Sensitometer.—The author describes a visual sensitometer used in researches on the eye, the chief feature being the formation of a spot of light of variable size and of intensity alterable between wide measured limits. With this apparatus the amount of radiant energy just giving rise to a visual sensation was found to average $19 \cdot 5 \times 10^{-10}$ erg per sec. But the value is much affected by physiological condition, state of adaptation of the eye, and size of visual angle presented by the illuminated area; as the visual angle increases, the minimum radiant energy becomes less. Diagrams illustrating the adaptation of the eye and consequent increase in sensitiveness when transferred from relatively bright surroundings to a dark room are also presented. The converse process of adaptation, *i.e.*, from darkness to light, proceeds more rapidly. If a stimulus in a dark room is seen at all it is usually recognised within 2 secs.; up to this interval sensibility rapidly increases, beyond this exposure the sensibility tends to decrease. Over a range of several thousand to one the eye can detect differences in brightness of 1 to $\frac{3}{4}$ %. To a fully dark-adapted eye a light of 25 units was judged glaring, but an eye adapted to bright sunlight can just tolerate 16,000 units. A curve connecting hue sensibility and wave-length is next presented. About 128 distinct hues can be recognised with the author's apparatus between 400 and 700 $\mu\mu$. Intensity also affects this quantity. Thus there are 700 perceptible shades of grey. There are probably over 30,000 distinct visual sensations including complex shades. In the *discussion,* **Edridge Green** remarked that with his instrument only 18 different pure colours could be recognised by the average eye, but **K. Mees** said that it was a recognised fact that people could see more than 100 colours. **F. J. Cheshire** suggested that this difference in results might be ascribed to the greater sensitiveness obtained by a very sharp boundary between the two surfaces compared.

J. S. D.

1254. *Supposed Weight and Ultimate Fate of Radiation.* **O. J. Lodge.** (Phil. Mag. 41. pp. 549–557, April, 1921.)—An attempt is here made to trace consequences, if light be subject to gravity in any real sense. Given a material universe, spherical and of radius R, with a uniform distribution of density ρ, *e.g.*, with equally distributed masses and great interspaces, the average interior force at distance v from the C.G. will be $-\frac{4}{3}\pi\rho G r$, where G is the Newton gravitation constant, and the potential then will be $2\pi\rho(R^2 - \frac{1}{3}r^2)G$. The speed of anything amenable to gravitation will then be a maximum near the centre and a minimum near or outside the periphery, so that light unable to escape would accumulate near the boundary, and if liberated by an expansion or other catastrophe, would burst into a blaze, rapidly rising in intensity and then dying away gradually during the time taken by the deeper-seated portions of the luminous shell to rise to the surface. By considering the speed acquired by a heavy body falling—from periphery to centre, from ∞ to surface, from ∞ to centre—it is seen that to prevent light from centre escaping entirely, and reaching the surface, respectively, the values of ρR^2 would be $c^2/4\pi G$, and $3c^2/4\pi G$; while to control light from surface into an orbit, ρR^2 would have the intermediate value $3c^2/8\pi G$. All these are of the same order, so that a system able to control and retain its light must have a size and density $\rho R^2 = 1{\cdot}6 \times 10^{27}$ c.g.s. It is hardly feasible for any single mass to satisfy this condition, either density or size being too enormous. But a stellar system—say a super spiral nebula—of aggregate mass equal to 10^{16} suns, say 10^{49} gm., might have a group radius of 10^{21} cm., with a corresponding average density of 10^{-15} c.g.s., without much light being able to escape from it. This does not seem an utterly impossible concentration of matter. But the average empty space enclosing each "sun" would have a radius only about 22 times the distance of Neptune, and the suns would subtend nearly $1''{\cdot}5$, as seen from each other. If light has weight in any real sense, it is tempting to treat it as a gas of low molecular weight and great velocity, for since its pressure = energy per cm.^{3}, $p = \frac{1}{2}\rho c^2$, it obeys Boyle's law like a gas of uniform very high temperature, the $\frac{1}{2}c^2$ taking the place of $\frac{1}{3}a^2$, the motion of light being one- or two-dimensional. The density of solar radiation at the earth's distance can be estimated from the measured pressure as of the order 10^{-25} gm. per cm.^{3}. Elsewhere, for gravitational potential V and gas-constant $p/\rho = k$, the density should be $\rho = Ae^{-V/k}$ if it is like one of the atmospheric gases. Now it does not seem likely that the speed of light escaping from a spiral nebula and managing to reach the earth has been so retarded *en route* that it arrives with less than normal speed. It is unlikely that a ray travels quicker as it approaches a gravitative mass. What observations show is that pursuing rays are deflected towards such a mass, the effect of gravitation being therefore to reduce the speed below normal, never to increase it. For the deflection is as if space, *i.e.*, the ether, had the refractive index $1 + 2V/c^2$ in regions of gravitational potential V. The retarding effect of matter appears felt before the substance is actually entered, as if matter could act optically, as gravitationally, by mere proximity. Therefore it seems incorrect to attribute weight to light—the deflection must be optical, not mechanical. The ether is affected by gravitational potential—the tension set up in it by a mass—so that its refractive index $\sqrt{(\mu\kappa)}$ is increased. The property corresponding to rigidity, $2\pi/\kappa$, is probably reduced by the gravitational tension or reduction of ether pressure, GM/r, caused by proximity of matter, as suggested in a previous paper [Abs. 505 ((1920)].

The author then considers the optical behaviour of a very extensive and concentrated stellar system, using Einstein's method of calculation, and avoiding the conceptions of ordinary weight as applicable to light. He starts with the Schwarzschild-Minkowski-Einstein equation $ds^2 = 1/\gamma \, . \, dr^2 + r^2 d\theta^2 + r^2 \sin^2 \theta d\phi^2 - \gamma c^2 dt^2$, where γ is a numerical factor involving a potential due to neighbouring gravitational matter—say a mass m at distance r—a factor nearly unity in ordinary cases, and more generally, such that, if V is the internal gravitational potential, $\gamma = 1 - 2V/c^2$. Then where no gravitation $\gamma = 1$, and therefore $ds = 0$. And ds is invariant and independent not only of axes, but of steady motion. Hence ds remains zero when γ is not unity. Thence it would follow that for a ray inclined at angle ϵ to a radius vector, $v/c = \gamma \sec \epsilon/\sqrt{(1 + \gamma \tan^2 \epsilon)}$. The reciprocal of this is the refractive index in a gravitational field, which, to a first approximation, is $\mu = 1 + 2GM/rc^2$ radially, and $1 + GM/rc^2$ tangentially. Hence, incidentally, the author's whirling discs experiment could give no positive result even had they been so absurdly massive as to cause a gravitational potential comparable with that at the sun's surface. Similarly the Michelson-Morley experiment, even on a mass as big as the sun, might still be expected to give a null result. Not only does Einstein's method make the speed of light a minimum where ordinary gravitational considerations would make it a maximum, but makes it assume a velocity characteristic of its position at each moment, without reference to past history. Also, for the stellar system considered above, an aggregate mass $\rho R^2 = 1 \cdot 1 \times 10^{27}$ c.g.s. would reduce light at its centre to relative rest. The author asks, further :—Is it possible that some of the radiation poured into space is trapped, without absorption, by reservoirs of matter, and held until they burst into stars ? Does light, when in free though modified ether it is stopped relatively to a gravitational mass, retain its energy, mainly in rotational form, tie itself into electrons, and add to the mass of the body ? Referring to J. J. Thomson's theory of refraction [Abs. 1122 (1920) and Phil. Mag. 40. pp. 713–734, Dec., 1920] and to the suspected tendency of a wave-front to break up laterally and concentrate into *quanta*-like units akin to those whence it arose, it is suggested that a concentration, both lateral and longitudinal, of momentum, and its localisation in specks, near matter or in an intense electric field, is to be anticipated. Moreover, the density of ordinary sunshine near the earth, being $\frac{1}{2}p/c^2$, is of the order 10^{-25} gm. per cm.^{3} : so if 10 cub. mm. of earth sunshine, or the equivalent of 1/4600 mm.^{3} of solar emission, could be checked and condensed till its density was 10^{12} it might be converted into an electron of mass 10^{-27} gm. Its original momentum, 3×10^{-17}, will presumably be communicated or restored to whatever stopped its translation ; while the energy of the light $= c^2 \times$ mass, will become the constitutional energy of the electron, whose intensive circulation must therefore be of the same order as c. Einstein's presentation of the kinetic energy of matter is $mc^2 + \frac{1}{2}mv^2$, the first term being apparently the constitutional energy of each ultimate particle. On this view the interior of an enormous stellar system might be the seat of a generation of matter of different type from that suggested by Eddington [Abs. 1565 (1920)]. If the concentrated and controlled luminosity were locked into an electron, its existence would be permanent. Could a group of half-formed, or half-shattered, units go about together in an unstable state, as globe-lightning, and be liable to explode back into light again ?

O. J. Lodge. (Nature, 107. p. 169, April 7, 1921.)—The author points out that, assuming that Rayleigh's result [Abs. 1141 (1916)] for the area of wave-front which can be tapped and have its energy extracted by an infinitely small resonator, viz., something comparable with λ^2/π, holds generally to a fair degree of approximation, the length of a ray of terrestrial sunlight sufficient for an electron is given by $l\lambda^2/\pi = 0 \cdot 01$ cm. or $l = 3 \times 10^7$ cm. for $\lambda = 3 \times 10^{-5}$, which would pass in the thousandth of a second. He asks if Bragg would be tempted to try whether corpuscles are still projected by radiation reduced in intensity, not continuously, but intermittently, by a revolving slit, and observes that if there is a critical length of effective beam, it would be instructive to know it.

J. Joly. (Nature, 107. p. 203, April 14, 1921.)—Joly gives a pre-

liminary description of arrangements recently planned and partly carried out by J. H. Poole and himself in order to test the very point raised by Lodge in his last question, and also to seek for evidence respecting the quantum theory of vision. At present there is only Halliburton's statement that a flash of $1{\cdot}25 \times 10^{-7}$ sec. duration is still visible. This (if it is the limit) affords 4×10^{3} cm. for the length of a wave-train activating an electron in the retina. If it be allowable to go further, the energy of a single wave (of green light) is found to be about 6×10^{-20} erg.
G. W. DE T.

1255. *Size Frequency Distribution of Particles of Silver Halide in Photographic Emulsions and its Relation to Sensitometric Characteristics.* **E. P. Wightman** and **S. E. Sheppard.** (Eastman Kodak Co.'s Research Lab. Comm. 103. J. Phys. Chem. 25. pp. 181–195, March, 1921.)—Although the existence of some relation between size of grains in a photographic emulsion and the sensitiveness of the emulsion was accepted early, little attention appears to have been paid to the variation in grain size in one and the same emulsion or layer, as a factor in the photographic properties. Attention was first called to this by C. E. K. Mees [see Abs. 848 (1915)]. The present paper is an introductory one, and deals mainly with the results obtained by other workers. It is, however, pointed out that a first result of the authors' experimental work is to show that the frequency curve alone is of less value in relation to the sensitometric curve than is the projective area curve obtained by plotting the product of frequency by the projective area of grains of a given class against the corresponding classes.
A. E. G.

1256. *Theory of Development of Latent Images.* **M. Volmer.** (Zeits. wiss. Phot. 20. pp. 189–198, March, 1921.)—A theoretical discussion which claims to show that the process of development can no longer be regarded as merely a super-saturation phenomenon, but as a case of heterogeneous metal catalysis.
A. E. G.

1257. *Action of Light on the Photographic Plate; the Photochemical Law of the Silver Halide Grain: a Criticism.* **L. Silberstein** and **S. E. Sheppard.** (Phot. J. 61. pp. 205–206, April, 1921.)—Slade and Higson in a paper on the photochemical law of the silver halide grain [Abs. 354 (1920)], state that "If it is assumed that light is discrete, and that it is only necessary for one of the light-quanta to be absorbed by a grain to make it developable, then a being the original number of grains, and n the number made developable in the time t, $dx/dt = kI(a - x)$." This statement is here criticised. Attention is also directed to some doubtful assumptions made in regard to experimental conditions. Thus the statement as to the number of layers of grains in a commercial process plate seems strongly underestimated; still more doubtful is the assertion that for fast plates there will be only one to two layers. The equality of the grains in a process emulsion is derived from visual examination only, and is not confirmed by actual measurements. The use of the value $0{\cdot}7\mu$ for the diam. of the grains in the calculation of the *thickness* is questionable, since the majority of the crystalline grains are thin flat tablets whose thickness will be much less than their greatest diameter.
A. E. G.

1258. *Action of Light on the Photographic Plate.* **G. I. Higson.** (Phot. J. 61. pp. 144–152, March, 1921.)—In Part I of this paper [see

Abs. 853 (1921)], the characteristic curves obtained in practice were compared with those theoretically deduced from known data for a plate of one layer of equal-sized silver bromide grains. During this comparison it became evident that the most striking similarities should occur in the under-exposure region, since in most cases the conditions in this region approximate to those holding in single-layer even-grained plates, as the light action in this region is confined almost entirely to the "first layer" of grains in the plate. By "first layer" is meant not the actual top "slice" of the film, but all those grains upon which light directly impinges without sensible diminution of intensity in its passage from the surface of the film (some of these grains may be quite near the back of the film). That the light action is so limited is obvious on microscopical examination of the under-exposed portions of a negative, but a further confirmation is given by a consideration of the average number of "layers" usually present, which under ordinary conditions is only small. In the present paper the under-exposure region of plates exposed to an intensity scale and the under-exposure region of plates exposed to a time scale are theoretically considered. The following points arising out of the theoretical investigation are experimentally investigated:—(1) The conditions under which the under-exposure region of the D, E curve is "hooked"; (2) the constancy of the length of the intercept for differing degrees of development; (3) the value of the exposure (*i.e.* $E = It$) at the point of intersection of the tangent (*i.e.*, the numerical value of λ in candle metre seconds) as a measure of the speed of the plate.

The following is the summary for both parts of the paper:—The data obtained elsewhere regarding the photochemical behaviour of the silver bromide grain have been extended so as to give a rational explanation of certain phenomena observed in the photographic plate itself under varying conditions of exposure, viz. (*a*) The existence of a "characteristic curve"; (*b*) the constancy of inertia; (*c*) the Schwarzschild-effect; (*d*) the "hooked" form of the D, E curve. Another property of plates independent of the development has been deduced, namely, the length λ, of the intercept on the E axis in the "hooked" form of the D, E curve. This is suggested as a measure of the speed of plates, intended for use under "high speed" conditions, $20/\lambda$ giving plate speeds of the same order as the H and D speeds at present in use. A. E. G.

1259. *Illumination and Time of Exposure in Photomicrography.* **G. Hansen.** (Zeits. wiss. Phot. 20. pp. 220–227, March, 1921.)—A series of tables is given with the help of which it is claimed that the time of exposure can be calculated beforehand, approximately correctly for every case. A. E. G.

1260. *Absolute Retardation of the Kerr-Effect and a New Application of the Experimental Method.* **Pauthenier.** (Comptes Rendus, 172. pp. 583–586, March 7, 1921; also J. de Physique et le Radium, 2. pp. 183–196, June, 1921.)—*Absolute Retardation.*—The method previously employed [Abs. 623, 927 (1920)] has now been used to measure the retardation in chlorbenzine, the value −2 being found as theory requires.

Kerr Constant.—Two condensers, one containing a standard liquid, CS_2, and the other the liquid to be tested, are placed between the crossed nicols. The axes of these condensers are parallel, but the plates of one vertical and of the other horizontal. The direction of vibration of the light is at 45° with the horizontal. When the charge is passed the light is in general restored, but can be extinguished by adjusting the distance apart of the plates of one condenser. With this arrangement the Kerr constant has been measured for water, ethyl alcohol, and mixtures of water and alcohol of varying concentrations. L. L.

1261. *Arc Spectrum of Iron.* **H. Schumacher.** (Zeits. wiss. Phot. 19. pp. 149–158, Nov., 1919.)—The measurements, made with the vertical iron arc of 4 amps. at 20 volts, 6 mm. in length, were checked by observations of arc lines of copper, silver, and nickel, and the poles were changed after intervals of 4 seconds. Comparison is made with the tables of Kayser and Runge, and an accuracy of 0·03 Å.U. is claimed. A Toepfer spectrograph was used. H. B.

1262. *Vacuum Arc Spectra of Sodium and Potassium.* **S. Datta.** (Roy. Soc., Proc. 99. pp. 69–77, April, 1921.)—Rayleigh [Abs. 381 (1920)] showed that an improved form of sodium-vapour lamp gave extremely narrow bright lines. This lamp was used as a source, and measurements were made of the wave-lengths of the sharp and diffuse series of sodium lines. A similar lamp was used for corresponding measurements of the potassium lines. Channelled-space emission bands were observed in the sodium-vapour lamp, and the heads of these bands were approximately measured. The combination line $1s–2d$ in potassium was resolved into a pair, the measured wave-lengths being $\lambda 4642 \cdot 172$ and $\lambda 4641 \cdot 585$.

Presence of Potassium in the Sun.—The presence of potassium in the sun has been established, the first pair of principal lines, $\lambda 7664 \cdot 94$ and $\lambda 7699 \cdot 01$, having been identified. Meggers' work confirms this.

Some additional sodium lines have also been identified with solar lines. A. W.

1263. *A Mechanical Theory of Series Spectra.* III. *The Vibration Frequency of Röntgen Rays and Atomic Weight.* **A. Korn.** (Phys. Zeits. 22. pp. 148–150, March 1, 1921.)—According to previous communications by the author [see Abs. 370 and 855 (1920)] the atomic vibrations of the visible spectrum arise in that negative electric particles which in general are influenced by electric forces, execute rapid rotations about an atomic nucleus, and are caused to move in inner orbits by disturbances through which the electrical forces are overcome by central forces of special form. The author has also previously shown what must be the nature of these central forces in order that series of the Kayser–Runge type may be given (in the simplest case to a Balmer series), and how such central forces can arise mechanically in consequence of the vibrations of the nucleus and of the rotating particles. The characteristic of these central forces is that for their production the compressibility of the medium must be introduced. Only central forces of the form: $f(r) = F^1(r)$, $F(r) = (\alpha + \beta/r^2) \cos 2\pi r/\lambda + 2\pi v/3\lambda r3 \sin 2\pi r/\lambda$, in which λ is a very small length, may be so explained. The author now describes the origin of the Röntgen-ray expression. The negative electric particles rotating in the inner orbits describe small circles about the nucleus in exceedingly small periods. When these orbits are altered a little by external disturbance, oscillations arise by which the circular orbits are transformed into elliptical ones of small eccentricity, and these oscillations are propagated in the medium as Röntgen rays. To support this conception the author shows that the frequencies of these oscillations are, as a first approximation, inversely proportional to the squares of the atomic weights in the case of chemical elements. This conception is in agreement with the assumption of other theories that disturbances which give rise to Röntgen rays occur essentially nearer the atomic nucleus than those which produce the series in the visible spectrum. H. H. Ho.

1264. *Absorption Spectra of Potassium Ferro- and Ferri-cyanides.* **F. H. Getman.** (J. Phys. Chem. 25. pp. 147–159, Feb., 1921.)—The absorption spectra of potassium α- and β-ferrocyanides are found to be identical, the non-isomeric relationship between the two forms being thus supported. A slight but well-defined difference between the absorption spectra of the α- and β-ferricyanides of potassium has been established, this confirming Locke and Edwards' statement that these salts are isomeric. Between the absorption spectra of potassium ferro- and ferri-cyanides a marked difference exists. On the assumption that the presence of an absorption band indicates a condition of potential tautomerism within the molecule, it is shown that a modification of the structural formulæ proposed by Friend for the ferro- and ferri-cyanides of potassium offers an opportunity for tautomeric charge and hence affords a possible explanation of the presence of bands in their absorption spectra. Further, it is pointed out that the relative number and positions of the tautomeric groups within the molecule may possibly be the cause of the marked difference between the absoption spectra of the ferro- and ferri-cyanides of potassium. T. H. P.

1265. *Infra-Red Absorption Spectra of Vegetable Oils.* **K. S. Gibson.** (Am. Oil Chemists' Soc. [2 pp.], 1920.)—The *spectral transmittance curves* for various vegetable oils are found to be virtually identical between 850 and 1360 $\mu\mu$, quite independently of the colour and of the location and magnitude of the bands in the visible region of the spectrum. The infra-red absorption bands are a property of the oil itself rather than of the chlorophyll or other colour-producing substances. T. H. P.

1266. *Spectrum of Hydrogen Positive Rays.* **L. Vegard.** (Phil. Mag. 41. pp. 558–566, April, 1921.)—G. P. Thomson has recently published some results of investigations with regard to the light produced by positive rays in hydrogen [Abs. 82 (1921)]. He there describes a study of the light-emission of positive rays of different composition, and according to his interpretation of the results the positive rays themselves in the molecular form should emit the so-called second or many-lined spectrum of hydrogen. This would mean that the second spectrum should show a Doppler-effect—a result which, according to the author, is opposed to all evidence so far obtained. The author refers in this connection to series of papers published by him in Ann. d. Physik from 1912 to 1917. Here he gives the results of investigations with regard to the laws governing the light-emission of positive rays. On the basis of these results he now criticises Thomson's results. **G. P. Thomson** (*ibid.*, pp. 566–567, April, 1921).—Thomson replies to Vegard's criticisms. A. B. W.

1267. *Einstein Spectral Line Effect.* **H. J. Priestley.** (Phil. Mag. 41. pp. 747–749, May, 1921.)—The prediction of the Einstein displacement of spectral lines is based on two assumptions : (*a*) the atom behaves as a natural clock, giving a value of *ds* which is the same for each vibration; (*b*) the time period *dt* of a vibration is transmitted by the radiation from the source to the observer. If we assume as an alternative to (*b*) that the Einstein interval *ds* is transmitted by the radiation, the effect will arise on the transference, not of the source, but of the observer to a different gravitational field. The present paper discusses the reasonableness of rejecting (*b*) and adopting the alternative. The deflection of the ray can be established on the alternative assumption without using the principle of least time, and arguments are adduced which suggest that the alternative is more in accordance with the ideas of relativity. A. W.

1268. *Spectrophotometry in the Visible and Ultra-Violet Spectrum.* **T. R. Merton.** (Roy. Soc., Proc. 99. pp. 78–84, April, 1921.)—A description has previously been given [Abs. 1132 (1917)] of the use of the neutral wedge for determining the intensities of spectrum lines, and results obtained by the method for hydrogen and helium have been given [Abs. 865 (1921)]. Certain features of the method, however, limit its application; in particular, the density of the "neutral" wedge increases with the wave-number, and for the investigation of the ultra-violet down to λ2000 the method is at present inapplicable.

A new method is here described which, whilst not superior to the wedge method in accuracy, has the advantage that it can be used in any part of the spectrum which can be photographed through quartz lenses and prisms, and its application to the extreme ultra-violet beyond λ2000 should present no serious difficulty. The method consists in crossing the dispersing system, *e.g.*, the prism of the spectrograph, with a very coarse grating, and reducing the length of the slit to a very small value. The grating is inserted between the prism and the camera lens of the spectrograph with the rulings perpendicular to the refracting edge of the prism, and a continuous spectrum thus appears on a plate as a dark central strip with a succession of other strips of different intensities on either side, the intensities of these orders being determined by the ruling of the grating, and the width of the strips by the length of the slit. In the case of a line spectrum, the lines are found to consist of dots of different intensities on either side of the central dot. If the last dots which are just visible in the case of two lines are noted, a previous knowledge of the relative intensities of the different orders corresponding to these dots at once enables the relative intensities of the lines to be determined.

Application to Stellar Spectra.—The fact that the slit is reduced to a point not only enables different regions of a light-source to be investigated without difficulty, but suggests application of the method to the study of stellar spectra. Valuable results relating to the black-body temperatures of stars might be obtained with telescopes of moderate dimensions with the aid of an objective prism. A. W.

1269. *Sensibility of Spectral Lines; Application to Astronomical Physics.* **A. de Gramont.** (Comptes Rendus, 172. pp. 893–896, April 11, 1921.)—The question of the sensibility of spectral lines seems to have received little attention in assigning the lines of the solar spectrum (for example) to the different elements, particularly where two different elements give lines very close together. In Rowland's table the following are found: λ3774·480 . . . Yt ?, λ3600·880 . . . Yt, Fe. The author's work [Abs. 438 (1921)] has shown these two lines to be among the most sensitive, and even the ultimate, lines of yttrium, both in the condensed spark, with or without inductance, and in the arc. The second line is, for iron, of altogether secondary importance, if even it belongs to it. Other similar cases are given.

A certain number of the elements are considered as absent from the solar atmosphere because none of their lines have been identified in the spectra of the total light or of the different parts of the sun: these are B, P, As, Sb, Bi, S, Se, Te, F, Cl, Br, I, Au, Hg. Without recourse, as has been done, to considerations of high atomic weight, or density of vapour, which do not apply in any way to half these elements, the simple examination of the table of lines of great sensibility recently given [Abs. 438 (1921)] shows that (1) S, Se, F, Cl, Br, I exhibit no ultimate lines, nor lines of great sensibility; they give also no arc spectra. (2) B, P, As, Sb, Te, Au, Hg have ultimate lines, as well as lines of great sensibility, in the region of the spectrum cut off by the earth's atmosphere, *i.e.*, of wave-lengths below the limit λ2920. (3) Boron has two strong arc (and also spark) lines λ2498, λ2497 which, as Rowland observed, would be absorbed by the air; but it also has a strong line λ3451 in the condensed spark without self-induction, which with salts in fusion has great sensibility, and which might be found in stars, since these are the seat of strong electric discharges, if instruments are employed with crown-uviol or quartz lenses. (4) Such arrangements would allow of the detection also of two antimony lines λ3268, λ3233, which are of great sensibility in the spark spectra of alloys. The same would apply to the principal ultimate line λ3068 of bismuth, whose other ultimate lines, or lines of great sensibility, would be stopped by the air. A. W.

1270. *Absorption Spectrum of Hydrogen Chloride.* **W. F. Colby** and **C. F. Meyer.** (Astrophys. J. 53. pp. 300–309, May, 1921.)—*Hydrogen-chloride absorption band,* 3·16 *to* 3·70 μ.—Because of the great theoretical interest attached to the absorption spectrum of HCl, the authors have undertaken to add experimental data. For most of the observations an absorption chamber 60 cm. long which could be heated to incipient redness was used, since Paton had found that as the temperature is raised the number of observable lines is increased while there is no *shift due to temperature.* These results were confirmed. The mean *wave-numbers for* 28 *lines,* 20 of which have shorter wave-lengths than the centre of the group, are given. The *law of spacing* is not parabolic, as has been supposed, but a cubic term is found to be necessary. The wave-numbers are given by the equation $\nu = 28{,}863 \cdot 60 + 205 \cdot 82\, n - 3 \cdot 082\, n^2 - 0 \cdot 165\, n^3$ the mean difference between observed and calculated being 2. The cubic term cannot be due to overlapping of lines at the base. The results obtained by Paton at 250° C. have been reduced. An explanation of the deviations from Imes's results is suggested. Only slight evidence of the *existence of a satellite* on the long-wave side of each line was obtained. No compensation chamber was used in these experiments, as a direct test showed it to be superfluous. AUTHORS.

1271. *Wave-lengths of Lines in the Iron Arc from Grating and Interferometer Measures* λ3370–λ6750. **C. E. St. John** and **H. D. Babcock.** (Mt. Wilson Observat. Contrib. No. 202. Astrophys. J. 53. pp. 260–299, May, 1921.)—*Wave-lengths of Iron-arc Lines from* λ3370 *to* λ6750;

Grating and Interferometer Measurements.—To avoid errors due to pole-effect a 12-mm., 5-amp. Pfund arc was used. This arc has also the advantage of yielding very sharp lines. To eliminate instrumental errors, spectrograms made with two Michelson and three Anderson gratings and with four pairs of interferometer plates were compared. A table is given containing the mean *results for* 1026 *lines*, of which 976 were measured on each of from 1 to 62 grating spectrograms and 576 on each of from 1 to 39 etalon spectrograms. The agreement shown indicates that for most of the lines the weighted mean wave-length is accurate to 0·001 Å. In the case of 250 stable lines, the agreement with Bureau of Standards measurements is good. But for 46 lines of groups *c*5 and *d*, the Bureau measurements are systematically greater, the mean difference being 0·007 Å. due to *pole-effect in the 6-mm., 6-amp. arc*. Of 78 *International Secondary Standards* measured with the interferometer, 62 stable lines came out as follows: 53 within ± 0·001, 8 within ± 0·002, 2 within ± 0·003, and 1 within 0·004 Å. of the adopted values; while in the case of 16 lines belonging to groups *c*5 and *d*, the International values are systematically greater, the mean difference being 0·007 Å. due to pole-effect in the arcs used in the original determinations. Evidently these sources had the same order of pole-effect as the 6-mm., 6-amp. arc. *Ghosts and reversals* gave the same wave-lengths as those obtained from fine lines produced in the core of a lean arc. A comparison of readings from long and short exposures of the same lines showed no *intensity effect* in the case of interferometer measurements.

Spectroscopic Measurements.—(1) *Method of reduction of interferometer spectrograms.* The elimination of a gauge plate over the slit and the introduction of a plate constant, Kλ, which may be determined from measurements of the ring diameters alone, greatly reduce the labour of measurement and reduction, without decreasing the precision. (2) *Comparison of grating and interferometer.* The advantages and disadvantages of each are discussed. AUTHORS.

1272. *Luminescence in Inorganic Bodies.* **J. F. Corrigan.** (Chem. News, 122. pp. 133–136, March 24, 1921.)—A critical survey is given of this subject and of the various theories which have been propounded to explain its phenomena. T. H. P.

1273. *Precision-Measurements in X-ray Spectra.* IV. *K. Series, the elements Cu–Na.* **E. Hjalmar.** (Phil. Mag. 41. pp. 675–681, April, 1921.)—In a former part of this paper, M. Siegbahn has given an account of a precision-measurement of the Kα-line in the region Cu–Cl. [See Abs. 1397 (1919) and 1176 (1920)]. The author has continued these investigations, first, on the Kβ_1-line for the same elements, and second, on the Kα, and Kβ_1-lines in the region S–Na.

The first of these examinations was made with calcite as analysing crystal, the second with gypsum. The new vacuum spectrograph of Siegbahn and Stenström was employed. The wave-lengths of the various lines measured are given in a series of 13 tables which show, in addition to well-known lines, a number of faint lines (α_1', α_5, α_6, β', and β_3). A. B. W.

1274. *Structure of the L-series* (*Uranium*). **A. Dauvillier.** (Comptes Rendus, 172. pp. 915–917, April 11, 1921.)—The knowledge of the L-series of the elements of high atomic weight is far from complete. To remedy the omission so far as possible, the author has made a detailed study of the L-series of uranium by the method developed by M. de Broglie. Measurements have been made of 9 new rays in the uranium L-series spectrum. On the same plates are recorded three discontinuities (L-series) of absorption. **A. B. W.**

RADIO-ACTIVITY.

1275. *The γ-radiation and Liberation of Energy from Radium and Mesothorium.* **[Mme.] P. Curie.** (Comptes Rendus, 172. pp. 1022–1025, April 25, 1921.)—Radium and mesothorium are isotopic elements which up to the present have not been chemically separated. It is difficult also to distinguish between these substances (in equilibrium with their decay products) by measurement of the penetrating powers of their γ-rays. But it is possible to make the distinction by measurements of heat emission due chiefly to the α-rays, from these substances. The author makes a calculation of the difference to be expected and shows the practical possibility of determining by this method the amounts of Ra and MesTh in a mixture. A. B. W.

1276. *Isotopism of Mesothorium and Radium, and the Separation of these Elements from Barium.* **R. K. Strong.** (Am. Chem. Soc., J. 43. pp. 440–452, March, 1921.)—The author summarises his paper as follows:—

(1) 1100 gm. of barium sulphate containing mesothorium and radium, equal in γ-ray activity to 14 mgm. of radium (element), was extracted from 1000 kg. of monazite residues. About 80 % of the activity was due to the mesothorium.

(2) The radio-active elements were concentrated by subjecting the mixture to fractional crystallisation by the hydroxide method, whereby 60 % of the active material was obtained in 1·5 % of the barium compound. (This corresponds to 8·4 mgm. of mesothorium and radium in 17 gm. of barium chloride.)

(3) The rich fraction from the hydroxide crystallisation was fractionally crystallised as bromide and 76 % of the active material obtained in 5·3 % of the barium compound (6·4 mgm. of mesothorium and radium in 0·55 gm. of barium bromide).

(4) The ratios of mesothorium to radium in the rich and lean fractions from the hydroxide crystallisation were practically identical with one another and also with the ratio of these elements in the original barium sulphate. The ratio of the active elements to barium was over 7000 times as great in the rich fraction from the bromide process as in the lean fraction from the hydroxide process. These facts furnish further evidence for the isotopism of mesothorium and radium. A. B. W.

1277. *Long-range Particles from Thorium Active Deposit.* **A. B. Wood.** (Phil. Mag. 41. pp. 575–584, April, 1921.)—The results obtained in 1916 by Rutherford and the author [see Abs. 912 (1919)], relating to the long-range particles from thorium active deposit, have been confirmed. A re-determination of the ratio of the total number of long-range particles (ranges exceeding 8·6 cm.) to the total number of ordinary α-particles (ranges 5·0 and 8·6 cm.) gives a value 1 in 11,000, as compared with 1 in 10,000 obtained in 1916.

It has been shown that at least 90 % of these particles originate in the active deposit, whilst the remainder are probably produced by intimate collisions of α-particles with the oxygen atoms contained in the mica absorbing screen which was employed to stop the α-particles of 8·6 cm. range. Slight evidence has been obtained of the existence of high-velocity particles, probably hydrogen atoms, of ranges exceeding 11·3 cm. The proportion of these relative to the total number of long-range particles is probably not greater than 1 in 100. Thus it has been found that, relative to the number of ordinary α-particles (5·0 cm. and 8·6 cm. range):

(1) Number of 11·3 cm. particles (probably α-particles) emitted from ThAct deposit = 1 in 10^4 approx.

(2) Number of high-velocity oxygen atoms (range 11·3 cm.) produced by collision of α-particles with oxygen in mica screen = 1 in 10^5 approx.

(3) Number of particles of range exceeding 11·3 cm. (*e.g.*, hydrogen atom) = 1 in 10^6 approx.

Items (2) and (3) are only rough estimates based on slender evidence.
A. B. W.

1278. *Mass of Long-range α-Particles from Thorium C.* **E. Rutherford.** (Phil Mag. 41. pp. 570–574, April, 1921.)—It is well known that ThC disintegrates in two ways, with the emission of α-particles of 8·6 cm. and 5·0 cm. range at 15° C. In 1914, the author and A. B. Wood showed that a small number of particles—about 1 in 10,000 of the total—were expelled with the long-range of 11·3 cm. The range and number of these particles was determined by a scintillation method, and from the brightness of the scintillations it was supposed that the expelled particles were atoms of helium. Subsequent experiments by the author on the passage of RaC α-particles through various light elements, led to the suspicion that the 11·3-cm. particles were possibly oxygen atoms (from the mica used as absorbing screen) excited by close collisions. This, however, seemed unlikely as the number of long-range particles from thorium C was about 10 times greater than would have been expected on this hypothesis. In the course of recent experiments the author obtained some evidence that the particles of α-ray type of range 9 cm., appearing in oxygen and nitrogen, were not atoms of oxygen or nitrogen, but atoms of mass about 3. It was a matter of great interest to examine whether such atoms were liberated in radio-active changes in addition to atoms of helium of mass 4. Using a very strong source of active deposit (from radio-thorium of activity equivalent to 24 mgm. of radium) and deflecting the long-range particles in a magnetic field (using two different methods), the author succeeds in proving conclusively that the long-range (11·3-cm.) particles for ThC are ordinary α-particles of mass 4. The experiments described thus negative the idea that particles of mass 3 are ejected from ThC. Similarly no certain evidence was obtained of the emission of H-atoms. A. B. W.

HEAT.

1279. *Negretti and Zambra's Distance-reading Thermometer.* (Engineering, 110. pp. 736–737, Dec. 3, 1920.)—*Apparatus.*—A description of a new form of mercury expansion thermometer in which several sources of error are compensated for. Essentially the instrument consists of a steel bulb containing mercury, connected by a capillary tube to an indicator of the Bourdon gauge type. Errors due to variations in temperature of the capillary tube are automatically compensated for by making the capillary of material of high expansion and running throughout its length a wire of a material of low expansion. The diameter of the wire and tube are so proportioned that the change of volume with temperature corresponds to the volume change of the mercury in the annular space. The indicator is also of a novel type. The inner end of the Bourdon tube is connected directly to the pointer and, in order to obtain sufficient movement without the use of multiplying gears, the Bourdon tube consists of several coils in two layers. Compensation for temperature changes of the indicator is obtained by means of a bimetallic strip. The article concludes with a brief description of a special form of the instrument adapted for taking air temperatures on aeroplanes. E. G.

1280. *Differential Micro-calorimeter.* **L. Wertenstein.** (J. de Physique et le Radium, 1. pp. 126–128, Oct., 1920.)—*Apparatus.*—A description of a calorimeter consisting of two Dewar vacuum vessels inserted into holes in a large block of metal whose temperature can be regulated by a thermostat device. Differences of temperature are measured by means of 20 copper-constantan thermo-junctions. The two vessels must be identical thermally, *i.e.*, the calorific capacity must be made proportional to the thermal conduction. This can be attained by the use of additional thermal capacity where necessary. *Methods of use* :—Two methods of using the calorimeter are described—(1) By measuring the steady state when the heat evolution balances the heat leakage from the vessel; (2) by observing the variable state of temperature and calculating from the constants of the calorimeter.

The apparatus can be utilised for measuring the minute heat evolution on the solution of NaCl in water and in other thermochemical reactions. E. G.

1281. *A New Study of the Leucoscope; Application to Pyrometry.* **I. G. Priest.** (Optical Soc. of America, J. 4. pp. 448–495, Nov., 1920.)—The paper is a study of a forgotten instrument whose invention is attributed by Koenig and Brodhun to Helmholtz (*c.* 1878–82), but which is very similar to an instrument used by Rose about 1863 in the diagnosis of colour-blindness. The potentialities of the instrument as a means of investigating spectral distribution and colour-temperature was clearly appreciated by the above-named workers.

Principle of apparatus.—The essential principle of the leucoscope design is this : Two juxtaposed images of a rectangular aperture produced by double refraction are viewed through a Nicol prism and a variable thickness of crystalline quartz, the nicol being between the eye and the quartz, and the optic axis of the latter being coincident with the line of sight. To a normal observer, with "white" light illumination, the two images appear, in general, in complementary colours, of unequal brilliance. If another nicol be interposed between the doubly-refracting part (calcite rhomb) and the light-source, it may be set so as to equalise the brilliance of the two images, leaving them still complementary in colour. Trichromatic observers find the following phenomena: (1) For all thicknesses of quartz greater than about 9 mm. there are found certain positions of the ocular nicol (one in each quadrant), for which both images are very pale (very nearly white) and, accordingly, very nearly colour-matched. One may be a very pale blue, the other a very pale yellow; neither one may be recognised as more reddish than the other. This is the criterion for the leucoscope setting which may be made with considerable accuracy for thicknesses of quartz not much in excess of 20 mm. (2) For great thicknesses of quartz both images are very pale for *all* positions of the ocular nicol; consequently the setting by the above criterion cannot be made accurately.

Application to Pyrometry.—When used as a pyrometer the criterion for setting is only the so-called "sensitive tint," which must be carried in the observer's memory.

Like the Mesuré and Nouel pyrometer, of which perhaps it may be considered a special case, the leucoscope is strictly and purely an optical pyrometer requiring no auxiliary electrical apparatus. E. G.

1282. *A Comparison of Monochromatic Screens for Optical Pyrometry.* **W. E. Forsythe.** (Optical Soc. of America, J. 5. pp. 85–95, Jan., 1921.) —This is a continuation of a series of papers by the author dealing with the disappearing-filament type of pyrometer. The use of red, green, and blue monochromatic screens is discussed, and it is shown that while screens of any of the three colours can be used successfully, the red has the following advantages: (1) Since the radiation first visible is the red, readings can be made at lower temperatures with a red screen than with a green or blue. (2) For very high temperatures where the scale has to be extended by the use of a rotating sector the same reduction in apparent temperature is effected by a sector of greater transmission in the case of the red than in the case of the green or blue. This is an advantage, since the calibration of small transmission sectors is difficult. (3) The change in colour with wave-length is much less in the red part of the spectrum than the green, hence a red screen is less liable to colour-matching difficulties. (4) Screens of better quality are available in red than green. The spectral transmission curves show that the best red glasses have a very steep slope on the visible side, while the rapid falling off in the visibility curve of the eye gives them a sharp drop in luminosity on the other side. E. G.

1283. *Heat Distribution on Radiating Spherical Surface.* **K. Aichi.** (Phys. Math. Soc. Japan, Proc. 3. pp. 5–10, Jan., and pp. 34–40, March, 1921.)—A treatment of this problem is given as an illustration of the theory of the integral equation previously discussed [see Abs. 280 (1921)]. In the second paper the author shows, for a spherical surface, the method of solution by the Laplacian equation. J. W. T. W.

1284. *Mechanism of Energy Exchanges during Evaporation.* **R. Audubert.** (Comptes Rendus 172. pp. 375–378, Feb. 14, 1921.)—

For the work required to vaporise 1 gm.-mol. of a liquid the author deduces the equation, $MJL = \alpha\pi d^2 N + RT$, where M represents the molecular weight, L the latent heat of evaporation, α the surface tension of the liquid, J the mechanical equivalent of the calorie, d the diam. of the molecule, and N Avogadro's number. By means of this expression the value of d has been calculated for a number of liquids at each of two temperatures, the results obtained being in satisfactory agreement with those furnished either by the kinetic theory or by Bragg's work. Introduction into the above formula of the value of L obtained from Clapeyron's equation yields, on the assumption that α varies linearly with the temperature, for the variation of the vapour pressure with the temperature an expression of the same form as that deduced by Dupré, Hertz, and Nernst. Further, it is shown that the above equation leads to the Pictet-Trouton law, and that vaporisation is a discontinuous phenomenon in which the elementary amount of energy brought into action is about 10×10^{-16} erg, this being the quantity of energy necessary to evaporate a single molecule. Also, for a number of liquids the relation, $\alpha\pi N d^2 = K(T_c - T)$, is verified, the value obtained for K differing very little from those derived from Eötvös' law. T. H. P.

1285. *Mechanism of the Exchange of Energy during the Electrochemical Passage of an Atom to the Ionic State.* **R. Audubert.** (Comptes Rendus, 172. pp. 753–755, March 21, 1921.)—It has been shown [see preceding Abs.] that the elementary quantity of energy taking part in evaporation may be calculated by regarding the work required to vaporise a molecule as exerted against the forces of cohesion and by expressing it by a variation in the surface energy. The phenomena occurring in the dissolution of an electrode in the solution of one of its salts are now considered from the same point of view. The work required to produce this change may be regarded as composed of two terms: a term w relating to the work necessary to withdraw an atom from the surface of an electrode, and a term w' indicating the work effected in the passage of this atom to the ionic condition. For a gm.-atom of the electrode, we have $\epsilon Qn = Nw + Nw'$, where ϵ represents the solution tension of the electrode, Q a faraday, n the valency of the ion considered, and N the Avogadro constant. The term Nw' may be expressed as Jq, J being the mechanical equivalent of heat and q the heat of ionisation of 1 gm.-atom of the element considered. The value of Nw may be calculated from the heat of vaporisation according to the equation, $JL = Nw + RT$, and that of ϵ hence determined. The values thus calculated for a number of elements agree with the observed values except in the cases of cadmium and hydrogen.

The results indicate that phenomena apparently different such as dissolution, sublimation, and the electrochemical passage of an atom to the state of ion are similar from the energetic point of view; each of these takes place as a discontinuous energetic process corresponding with a quantum of about 18×10^{-16} T erg. T. H. P.

1286. *Constant-Volume Explosion Experiments.* **S. Lees.** (Cambridge Phil. Soc., Proc. 20. pp. 285–290, May, 1921.)—The volumetric heat of a gas at a high temperature, *i.e.*, its total internal energy divided by absolute temperature $(T - T_0)$ reckoned from zero T_0, can be determined either at constant pressure, or at constant volume with the heating produced by explosion in a closed vessel. The values obtained by constant-volume methods are always slightly greater than at constant pressure. Some part of this difference can be accounted for by the variation in temperature in different parts of an explosion vessel and the fact that the volumetric heat increases with temperature. Suppose the whole volume to be divided into portions $N_1, N_2 \ldots$ gm-molecules at abs. temperatures $T_1, T_2 \ldots$ and T_m to be the mean temperature of the mixture as measured by its pressure, then the internal energy found is greater than the true internal energy by the quantity $\frac{1}{2}B\Sigma N_1 t_1^2$, where B is the constant in the definition of the total internal energy $E = A_0T + \frac{1}{2}BT^2$ and t_1 the quantity $T_m - T_1$.

The problem is also treated graphically, and an explosion-vessel experiment of the late B. Hopkinson is taken as an example of applying the correction. It appears, however, that in no case is the correction likely to be greater than 1 %, which at present is within the limits of probable experimental error in such experiments. T. B.

1287. *Vapour Pressures and the Isothermals of Vapours.* **J. H. Shaxby.** (Phil. Mag. 41. pp. 441–454, March, 1921.)—A large number of empirical formulæ have been proposed to express the vapour pressure of a fluid in terms of the temperature and certain constants for the substance in question. Many of them, *e.g.*, those of Dalton, Roche, Biot, Kirchhoff, and van der Waals, are of exponential form, which recalls Dieterici's equation of state. The latter is discussed, and the relationship examined between the total internal pressure in the liquid phase of any substance, and that in its vapour phase. It is found that in ideal substances, the ratio of the occupied volume (co-volume) to the total volume of a liquid is equal to the ratio of the unoccupied volume to the total volume of its saturated vapour. The two phases, in equilibrium with each other, are complementary in this respect. The relation is nearly true for actual fluids. The equation, $p = RT(d_1 + d_2)(d_2/d_1) \exp. (d_1 + d_2)/(d_1 - d_2)$, is obtained for the saturation pressure of a vapour in terms of the temperature and the densities of the two phases at that temperature. This leads to an equation of state,

$$p[v - 1/(d_1 + d_2)] = RT(d_2/d_1) \exp. 2/(d_1 - d_2)v.$$

It is shown that the quantity $(d_1 + d_2)$ may be regarded as a density factor which is a measure of the cohesive forces per unit mass. On this hypothesis, that, for actual substances, there is a density proportional to the cohesive forces nearly but not exactly equal to $(d_1 + d_2)$, modified forms of the above equations are obtained. These equations express the experimental facts with considerable accuracy for all temperatures and pressures. Reduced forms of the vapour-pressure are obtained and an equation for the calculation of the critical density of a substance. This is found to give consistent values, even in cases such as that of water when the Mathias rule does not hold. H. H. Ho.

1288. *Vapour-pressures of Mixtures.* I. *Binary Mixtures.* II. *Extension to Systems of Higher Order.* **A. W. Porter.** (Faraday Soc., Trans. 16. pp. 336–345, Feb., 1921.)—The fundamental equation concerning the vapour-pressures of binary mixtures is the differential equation of Duhem, $\mu_a . \partial \log \pi_a / \partial \mu_a = \mu_b . \partial \log \pi_b / \partial \mu_b$, where μ_a and μ_b are the molar fractions of the components in the liquid mixture and π_a, π_b are the respective vapour pressures. This equation is nearly exact under ordinary conditions, though it assumes that the vapour mixture follows the law of perfect gases (in consequence of which the partial pressures of its components are additive), and further that the liquid volume is negligible compared with that of the vapours from it. These assumptions do not impair the utility of the formula excepting in those cases for which one or other, or both of the components, approach close to their critical points. The author now gives a proof of this important theorem to make the usual demonstration clearer. Examples are quoted where a simplified formula represents the experimental results. A discussion is then given of the controversy between Dolazalek, who espouses the chemical view, and van Laar, who adopts the physical interpretation. The following points are put forward for consideration: (*a*) The internal pressure which maintains a liquid in the liquid form is proportional to the square of the density for simple liquids, and, when a mixture is made product terms must enter representing the attraction of unlike molecules for one another which must in general be present so long as the liquid form persists; allowance must in every case be made for their effect. (*b*) Besides these effects, chemical changes (association, dissociation, combination) may also be present, but only occasionally, and must then be considered. It is shown that only special cases require the introduction of the chemical hypothesis.

Part II contains an extension to systems of higher order. A potential is shown to exist which implies the existence of a function undergoing no ultimate change in value if a cyclic series of positions is passed through; and this statement implies the validity of three equations derived by the author from equations of the Duhem-Margules type. The application to individual experimental investigations of this mode of obtaining theoretic values to the partial pressures of a mixture is deferred to a subsequent paper. H. H. Ho.

1289. *Reversible Heat Production.* **E. Altenkirch.** (Zeits. techn. Physik, 1. 4. pp. 77–85, and 1. 5. pp. 93–101, 1920.)—A general exposition of the principles of heat transformation and production with special regard to its technical utilisation. Technical detail is not given. A paper on the absorption machines of the author and others is to follow. H. B.

DISCHARGE AND OSCILLATIONS.

1290. *Brush and Glow Discharges of Electricity and Spark Formation.* **U. Yoshida** and **H. Hirata.** (Kyoto Coll. Sci., Mem. 4. pp. 89–103, Feb., 1920.)—I. *Brush Discharge.*—Brushes are observed between two metallic electrodes connected to a two-plate influence machine. With two spherical electrodes, separated by the proper distance and with small electrical capacity between them, positive and negative brushes appear: the negative, of a reddish-purple colour, ends in a diffuse boundary and never showing any branching; the positive shows the characteristic branching and consists of two parts—a more intense part of reddish-purple near the anode, and a weak part of bluish-purple farther away [as in previous experiments on photographic brush figures, Abs. 105 (1917) and 76 (1919)]. By reducing the electric intensity the weak part may be obtained alone, but the intense part is always accompanied by a weak part. With one electrode plane, the brush discharge takes place only at the spherical electrode. If the plane be kathode, by reducing the distance between the electrodes a state is reached when many fine positive brushes of weak intensity reach the plane but no spark passes. It is never observed that an intense branch reaches the kathode without causing a spark. With the sphere as kathode a spark appears to pass only when the weak diffuse luminosity occupies the whole space up to the anode. An explanation of the formation of these brushes is attempted by considering the ionisation of gas molecules by collision with electrons and positive ions. The stronger and weaker parts of the positive brush are different in their natures; the latter is a pilot of the former and the arrival of the intense part at the kathode or at a negative brush causes a spark discharge.

II. *Glow Discharge.*—When the distance between two spherical electrodes is increased the positive brush disappears and the surface of the anode is covered by a thin film of pale violet glow: the positive glow discharge. The authors repeated Wesendonck's experiment where it is shown that a positive brush may be converted into a glow discharge by blowing air against the former. This seems to be due to the rapid diffusion of great numbers of positive and negative ions in the brush so that any uniform supply of electrons towards the anode should favour the glow discharge. When a positive brush is formed and the region ionised by β- and γ-rays from radium bromide, the brush is replaced by the glow; the brush reappears on the removal of the β- and γ-rays. The same is observed with the negative brush but with more difficulty. If after the positive brush has been converted into the glow by the radium the electric intensity be increased, reddish-purple luminous points appear in the glow (Wesendonck's "der Zündstoff eines Funken"). A few brushes sometimes appear and start from these points; they are of the same nature as the intense parts of the ordinary positive brush.

III. *Spark Discharge.*—When the capacity between the electrodes is increased the brushes lengthen; on further increase of capacity a stage is reached where the discharge apparently only occurs in the form of sparks, never of brushes. It appears that the brushes have become so long that each causes a spark, the spark traversing the path of the brush. The spark is different in form according as it is formed from a negative or a positive brush. Photographs are given showing the zigzag spark formed from a positive brush and a straight spark from a negative brush. Explanations of other features of a spark discharge are attempted on the ground that a spark passes along the path made by a preliminary brush. T. H.

SOUND.

1291. *Selective Hot-Wire Microphone.* **W. S. Tucker and E. T. Paris.** (Roy. Soc., Phil. Trans. 221. pp. 389–430, March 3, 1921.)—This microphone was developed from the sound detectors used for sound-ranging. It consists of an electrically heated grid of fine platinum wire, placed in the neck of a Helmholtz resonator. The effect of a sound having the same frequency as that natural to the resonator itself is to produce an oscillatory motion of the air in the neck, which in turn causes a change in resistance of the Pt-wire grid. The paper describes the construction in detail. So far, frequencies up to 512 vibrations per sec. have been experimented with. The total resistance change comprises a steady fall in resistance due to an average cooling of the grid and a periodic change due to the to-and-fro motion of the air. Two methods of using the microphone are described: (1) A bridge method, depending upon the steady drop in resistance; and (2) an amplifier method which makes use of the periodic resistance changes. The microphone exhibits very sharp tuning, illustrated by curves obtained by the bridge method.

Sensitivity.—The most important factor affecting the sensitivity of the microphone is the variation with the heating current of the grid. The sensitivity always increases as the heating current is increased. In the case of the bridge method, the steady resistance change produced by a sound of given intensity is a linear function of the temperature of the grid above its surroundings.

The nature of the resistance changes and the means by which they are produced, are closely examined, and the relation between the resistance and the velocity of the air in the neck of the resonator is established by experiments on the cooling of the grid by low-velocity air-currents. From the results of these experiments it is deduced that the principal resistance changes to be expected when the grid is cooled by an oscillatory air-current are (1) a steady drop due to an average cooling, (2) a periodic resistance change at the same frequency as that of the sound, and (3) a periodic resistance change of frequency twice that of the sound.

All these effects are found in practice. Further deductions are that the steady change of resistance is proportional to the energy of vibration in the neck of the resonator, that is, to the *intensity* of the sound, while the periodic resistance change, (2) above, is proportional to the amplitude. These conclusions are confirmed by experiment. A description is given of the effects to be observed when the microphone is tilted at various angles, and the observed facts are compared with the deductions from the results of experiments with steady air-currents. The microphone is generally used with its axis vertical, the mouth of the resonator pointing upwards.

Application to Testing Sound Intensity and Distribution.—An account is given of some experiments which exemplify the use of the hot-wire microphone for observing the intensity and distribution of sound, particularly for testing trumpets, acoustic lenses, and mirrors and other sound-concentrating devices and also for investigating the reflection and diffraction of sound-waves generally. W. H. G.

1292. *United States Hydrophone.* **H. C. Hayes.** (Am. Phil. Soc., Proc. 59. 5. pp. 371–404, 1920.)—The MV type of hydrophone (here described) is the result of two years of intensive research carried out by the U.S. Navy. It was developed as an instrument of warfare. During the past year the Navy has discovered that the same qualities that enabled the MV hydrophone to detect and accurately determine the direction of a submerged submarine enables it to serve as a powerful aid in safeguarding navigation in times of peace, and it is the confident belief of those most familiar with its operation that this device is destined to save more vessels and lives than were destroyed during the war by the U-boats that brought about its development. The paper, by tables and a number of diagrams, graphs, and charts indicates what this type of hydrophone can accomplish but gives no details as to its construction and action. E. H. B.

1293. *Diaphragms capable of Continuous Tuning.* **L. V. King.** (Roy. Soc., Proc. 99. pp. 163–171, May 2, 1921.)—In submarine acoustic signalling a great advantage is to be derived by utilising a means of continuously tuning the diaphragms of the sound-receivers. By the application of gaseous pressure (or suction) over the interior of the diaphragm (in gas-tight connection with the body) it is caused to bulge out (or in); the frequency of the vibration natural to the diaphragm is accordingly changed continuously between certain limits. The results of experiments plotted in the form of graphs show very smooth curves, both for air and for water in contact with the diaphragm outside. E. H. B.

1294. *Nature of Vowel Sounds.* **C. de Wesendonk.** (Nature, 107. p. 12, March 3, 1921.)—To test the nature of vowels Wesendonk emphasises the need of using simple tones to build them, say, from bottles, blown across their mouths. It is also felt that the work of D. C. Miller in his "Science of Musical Sounds" and the researches of Stumpff of Berlin have shown Helmholtz's theory to be practically beyond doubt.

E. W. Scripture. In reply to the above Scripture quotes, from p. 130 of Miller's book, the distribution of energy in sounds from a tuning-fork, the voice, etc. He points out that these results are in agreement with the work of himself and that of Hermann. E. H. B.

1295. *Interference Beats Similar in Nature to those of Pendulums, Sychronous Motors, and Thermionic Valves.* **G. Benischke.** (Elek. u. Maschinenbau, 39. pp. 53–55, Jan. 30, 1921.)—A general article on the production of beats in two coupled systems either mechanical, acoustic, or electrical. The differential equations for an uncoupled forced oscillation system and for a pair of coupled forced oscillation circuits are given, but no attempt is made to give the somewhat involved mathematical solutions and the deductions which can be made from them.

The phenomenon of beat production is illustrated by the usual curve showing the resultant due to superposing two harmonic curves; and the application of the thermionic valve for beat reception in wireless telegraphy is dealt with. The same phenomenon in synchronous motors is then described and the analogous nature of the resistance factor in both cases is mentioned. The case of the pendulum of a clock is likewise dealt with. The question of strong and weak coupling of the two systems is mentioned, as well as the effects of strong damping and of negative resistance. B. J. L.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1296. *General Method of Continuous Electrical Integration.* **F. Brocq.** (Comptes Rendus, 191. p. 1139, Dec. 6, 1920.)—Given $y = f(x)$, plot the curve $(x, dy/dx)$ in rectangular coordinates on to a thin, rigid lamina of insulating material, together with the x-axis. Cut the lamina along each line and along the ordinates corresponding to x_0 and x_1, and wind it, parallel to the y-axis, with insulated wire bared wherever it crosses the x-axis. Then the resistance of the wire is proportional to the surface of the lamina, *i.e.*, to $\int[x_1, x_0] f'(x)dx$. A voltameter connected to x_0, and by a sliding contact to x, will measure the value of $\int[x, x_0] f'(x)dx$. G. W. de T.

1297. *Page's Electromagnetic Theory.* **H. Bateman.** (Nat. Acad. Sci., Proc. 6. pp. 528-529, Sept., 1920.)—The author shows that Page's lines of force [Abs. 1185 (1920)] can be found by solving a Riccatian equation, as in the usual electromagnetic theory, and, from the forms of his electric and magnetic vectors, Page's field is obtainable by superposing on the usual electromagnetic field a second field of type previously considered by the author [Lond. Math. Soc., Proc. (Sec. 2), 18. p. 95, 1910], by writing H for E and $-\mathsf{E}$ for H. Page's formula may be generalised to give a field in which both electricity and magnetism travel away from the electric pole with the speed of light. A pole of this type may describe a circular orbit without radiating energy, as in Bohr's theory of the H-atom, with radiation of Page's type during change from one orbit to another. The weak point of such a theory is that it requires the presence of electric and magnetic currents in the space surrounding the electric pole, which must contain a continuous distribution of electric and magnetic particles which have been emitted from the moving pole and are travelling along straight lines with the speed of light. G. W. de T.

1298. *Potentials of Moving Electric Charges.* **A. Liénard.** (Phil. Mag. 41. pp. 483–484, March, 1921. Comptes Rendus, 172. pp. 51–54, Jan. 3, 1921.)—The author observes that, in Anderson's paper [Abs. 691 (1921)], the statement that "If $A = \int\int\int \rho dx'dy'dz'/r[1 - u_r/c]$, then $\nabla^2 A - \ddot{A}/c^2$ will vanish at any point p where there is no electricity," holds only if the elementary volume $dx'dy'dz'$ and the electric charge be carried by the same motion ; which is not the case. Moreover, he proves that in the simple case of u being constant in magnitude and direction, in all points and at any time, $\nabla^2 A - \ddot{A}/c^2$ does not vanish. G. W. de T.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1299. *Influence of Light upon the Conductivity of Fluorescent Liquids.* **H. Soulan.** (Comptes Rendus, 172. pp. 581–582, March 7, 1921.)—Most of the determinations made with the object of showing the influence of light upon the conductivity of fluorescent liquids have furnished negative results. Those to which this does not apply are open to objections which render doubtful the conclusions arrived at. The author has shown

that an illumination of some seconds' duration of fluorescent solutions of eosin, æsculin, and curcumin in different solvents is not accompanied by variations of conductivity of the order $1/10^4$. But if, as Perrin has shown, the fluorescent state is accompanied by a chemical transformation of the fluorescing molecules, the prolonged illumination of a fluorescent liquid should lead up, by a variation of progressive conductivity, to the establishment of a limiting value corresponding to the complete transformation, and this limiting value should remain after a return to darkness. This has been verified in a certain number of solutions. A table is given showing the results obtained, and the formula $\log (c_\infty - c_t) = b - at$, in which c_t represents the conductivity at time t, c_∞ the limiting conductivity (a and b being constants characteristic of the fluorescing substance used), is found to be approximately verified for very dilute solutions.
A. E. G.

1300. *Dielectric Constants of Phosphores, and the Absolute Wave-lengths of their Long-duration Phosphorescence.* **F. Schmidt.** (Ann. d. Physik, 64. 8. pp. 713–732, April 29, 1921.)—A continuation of previous work [Abs. 669 (1921)]. The results now obtained show that the spectral positions of a phosphorescence band of the long-duration type are not constant, but depend both on the magnitude of the dielectric constant of the phosphorescent material and on the size of the phosphorescent centres. The absolute wave-lengths of the long-duration phosphorescence, obtained by dividing the observed values by the square root of the dielectric constant of the phosphore concerned, are characteristic of the phosphorescence bands. These wave-lengths are the same for corresponding bands for metals of widely different order number. Results obtained up to the present for these absolute wave-lengths show a definite connection between them and ordinary light-spectra, series relations of similar type being found for both. The metal atoms in the phosphorescent centres behave in respect to light absorption like atoms in free ether, their oscillations being influenced in a regular manner by the dielectric constants of the phosphores in question, and the oscillations may differ according to the position of the atoms in the phosphorescent centres. [See Abs. 810 (1910.)] A. W.

1301. *The Dielectric Constant and Electric Double-Refraction.* **R. Gans.** (Ann. d. Physik, 64. 6. pp. 481–512, March 31, 1921.)—Since the intramolecular forces and the interaction between molecules are of an electrical nature, the author opines it necessary to evolve a comprehensive theory of electrostatic polarisation and of electric double-refraction, in order to obtain a better insight into molecular structure, which still remains even more obscure than atomic structure. For this purpose, the orientation hypothesis appears to be especially suitable—namely, that the molecules are directed under the influence of electric fields. Langevin was the first to apply this hypothesis to double refraction under the assumption that the molecule is an oscillator with anisotropic union. Into the theory of dielectric constants, Debye introduced the directive hypothesis under the assumption that the molecule already possesses a permanent electrical moment which has not been first induced by the external field. He then showed that the dielectric constant, regarded apart from the influence of the dilatation of the body, is dependent on the temperature. Debye also investigated the case of the electric moment being altered by changes in the external electric field. Born [Abs. 934 (1918)] applied the same mechanism to the theory of electrical double refraction. The relatively meagre observations of the Kerr constant are also more or less in agreement with the Langevin theory, as, for example, the temperature dependence which Bergholm has observed. More recent measurements, however, cannot be explained by the Born generalisation, and the present paper deals with the causes of these discrepancies. In the author's opinion, the molecular fields have been neglected in previous investigations, support to this view being afforded by his own work on paramagnetism, in which the influence of temperature and density on magnetic susceptibility has been explained by taking such molecular fields into account. Previous theories are shown to form a limiting case for high temperatures and small densities analogous to the limiting case of ideal gases in the general equation of state for fluids. Section 1 of the paper considers the assumptions of statistical mechanics; section 2, double refraction; section 3, the molecular field; section 4, molecules of anisotropic union without fixed moment; section 5, molecules with fixed, non-induced moments; section 6, molecules with permanent and induced moments. The present paper is mathematical throughout, but an experimental investigation is in progress. H. H. Ho.

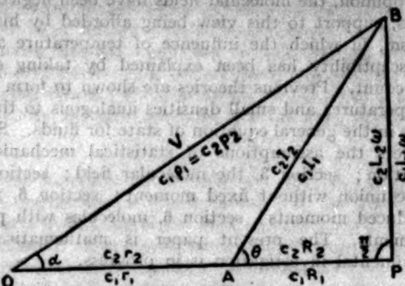
1302. *Measurement of Electrical Conductivity in Metals and Alloys at High Temperatures.* **J. L. Haughton.** (Faraday Soc., Trans. 16. pp. 392–401; Disc., 401, Feb., 1921.)—The value of the study of the electrical conductivity of alloys at varying temperatures as an aid to establishment of their equilibrium diagrams is referred to. The theory has been fully discussed by Guertler [see Abs. 128 (1911)]. A description of the apparatus employed in making the measurements is given in full detail and illustrated photographically and in diagrams; the devices adopted for overcoming difficulties arising from the high temperatures should be consulted in the original. In an investigation of the constitution of the Cu-Al-Zn alloys the liquidus and solidus over one range are too close to be distinguished by means of thermal curves, but marked changes in the direction of the curve connecting conductivity and temperature at both the solidus and the liquidus served as a valuable check on the thermal determinations. A thermal curve for a Cu-Sn alloy (60 % Sn) is plotted alongside a curve relating its electrical conductivity with temperature, and corresponding characteristic points are compared.

A. B. C. L.

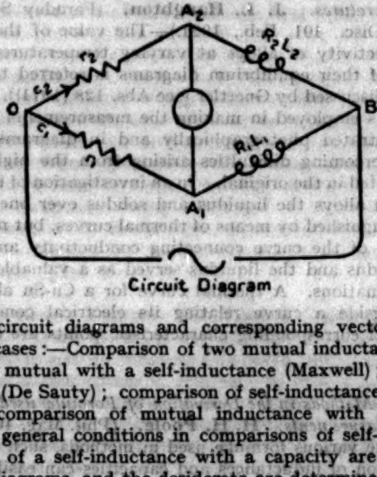
1303. *Vector Methods in the Derivation of Formulæ used in Inductance and Capacity Measurements.* **H. H. Poole.** (Phil. Mag. 40. pp. 793–809, Dec., 1920.)—The various formulæ used in methods, such as Anderson's, for the comparison of inductances and capacities can easily be obtained geometrically from the vector diagrams representing the currents in the various arms, and this method has the advantage of enabling a better mental picture to be formed of the circuit conditions. If the system is balanced, *i.e.*, the two terminals of the telephone or other detector are represented by a single point on the p.d. vector diagrams, certain relationships exist between the various arms which are independent of frequency. Similarly, since any disturbances can be resolved into sinusoidal components, the system is balanced for any disturbance whatever, provided that the inductances and capacities are independent of frequency.

The Fig. refers to comparison of two self-inductances by Maxwell's method. One point, O, in the system is taken as the zero of potential. A_1 is at the same potential as A_2, both being represented by A on the vector diagram. The current c_1 in OA_1 also flows through A_1B; similarly, c_2 flows through OA_2 and A_2B. The vector diagram therefore represents either the branch OA_1B or the branch OA_2B, and shows that: $c_1r_1 = c_2r_2$; $c_1R_1 = c_2R_2$; $c_1L_1\omega = c_2L_2\omega$. Hence $r_1/r_2 = R_1/R_2 = L_1/L_2$. The author gives circuit diagrams and corresponding vector diagrams for the following cases:—Comparison of two mutual inductances (Maxwell); comparison of mutual with a self-inductance (Maxwell); comparison of two capacities (De Sauty); comparison of self-inductance with a capacity (Anderson); comparison of mutual inductance with capacity (Carey Foster). The general conditions in comparisons of self-inductances and in comparison of a self-inductance with a capacity are investigated by aid of vector diagrams, and the desiderata are determined and explained.

R. E. N.



Vector Diagram



Circuit Diagram

1304. *Measurement of Electrolytic Resistance using Alternating Currents.* **H. F. Haworth.** (Faraday Soc., Trans. 16. pp. 365–386; Disc., 386–391, Feb., 1921. Electrician, 85. pp. 443–445, Oct. 15, 1920. Abstract.) —The experiments described are designed to ascertain the relation existing between the apparent resistance of a cell, as measured between the current-carrying electrodes, and the true resistance of the electrolyte as determined by other methods. A method is experimentally deduced showing how the true conductivity of a strong solution can be obtained from the variation of the apparent resistance with frequency, when it is measured in a low-resistance cell, using plain Pt electrodes. The apparatus employed in carrying out the experiments is described in detail and illustrated diagrammatically. To produce a sine-wave e.m.f. two alternators have their armatures connected directly with a motor driving shaft, thus eliminating backlash, and ensuring the necessary constancy of supply frequency. For the detection of p.d.'s on the bridges, etc., used, a Duddell vibration galvanometer is employed, improved by (1) the use of short pole-pieces, so that with short wires at high frequencies all the flux can still be sent through its moving system, (2) use of electromagnet so that flux can be varied to obtain the max. sensibility, (3) short-circuiting the inoperative part of the wire as the bridge pieces are brought together, thus reducing the effective resistance of the instrument, and allowing greater flux densities to be used. An electrically operated thermostat, actuated by toluene in a thin glass bulb, is described, capable of maintaining temperature constant within ± 1/1000 deg. C. : particular success is claimed for this thermostat. In the earlier experiments the cells are constructed with platinum and Jena glass : later the electrodes of one cell are platinised, and the resulting effects compared. The bridge arrangements are described and discussed theoretically in relation to calculation of results. The readings obtained with $N/10$ KCl are given, and a diminishing effect of frequency variation on resistance is observed. Dilution experiments are described and their results tabulated. It is observed that even using platinised electrodes, the resistance varies with the frequency, although for strong solutions the variation is small compared with that which takes place with non-platinised electrodes. It is also observed that dilution involves a decrease in the effective capacity of the cell. The large increase of capacity observed with platinised electrodes is discussed, and attributed to the effect of the Pt deposit on the gas film. Preliminary experiments using a Drysdale potentiometer are referred to and a table of results with KCl is given. A phase displacement of about ½ deg. between the voltage across the non-inductive anti-capacity resistance and the potential electrodes is detected. Owing to the amount of manipulation required in working the Drysdale potentiometer an arrangement consisting of an electrolytic cell in series with a shunted condenser and an ordinary—or a Crompton—potentiometer is employed. The features of this combination, and the method of operation, are described. Experiments are carried out on a saturated KCl solution with plain Pt current and potential electrodes, and with mercury potential electrodes. Platinised and non-platinised electrodes are again compared, and the results tabulated and discussed. In conclusion, it is suggested that the gas film behaves like a leaky condenser, its thickness and resistance depending on the strength of solution, the temperature, the current, and the frequency. The effect of platinising an electrode is not thought to be due to increase of area, but to absorption of the gas film, producing a short-circuiting effect.

In the *discussion*, **A. W. Porter** objected to the treatment of the gas film as a leaky condenser, pointing out that such may be replaced by a capacity with a resistance in parallel with it. This suggestion is represented in a diagram, developed mathematically, and applied to the results given in the paper for $N/10$ KCl non-platinised. **J. R. Partington** referred to the neglect of polarisation effects in the treatment of results.

In reply to A. W. Porter, the **Author** stated that the impedances of the electrolytic condensers at infinite frequency are zero, and the resistances of the double layers on the electrodes do not appear in the extrapolated resistance as suggested. A. B. C. L.

1305. *Conduction of Electricity through Fused Sodium Hydrate.* **A. Fleck** and **T. Wallace.** (Faraday Soc., Trans. 16. pp. 346–359; Disc., 360–364, Feb., 1921.)—The first objective of the present paper was to determine the specific resistance of fused caustic soda, but as the work progressed the scope was widened considerably, and the experimental work now described includes:—Preliminary experiments with sodium-hydrate solution; resistance between two electrodes in fused sodium hydrate; effect of altering the distance between electrodes; effect of altering the size of electrodes; change of resistance with temperature; change of decomposition voltage with temperature. It was found that if a constant current is passed between two electrodes placed closely together immersed in a mass of fused caustic soda, and the two electrodes are moved apart, then the resistance increases until a certain max. value is reached, after which it remains constant. The conduction of electricity across fused caustic soda by electrodes of different sizes has been studied, and an approximate idea has been obtained of the laws which govern the rate of change of resistance compared with the size of the electrodes. The rate of change of resistance between 320° and 480° C. for fused caustic has been found to be 0·102 % fall per 1 deg. C. rise in temperature. The decomposition voltage was found to be a variable quantity, decreasing at the rate of $2{\cdot}25 \times 10^{-3}$ per 1 deg. C. rise in temperature; this figure differs considerably from Neumann's, $2{\cdot}95 \times 10^{-3}$. A current has been passed through fused caustic soda between two sodium electrodes. Ohm's law was found to be obeyed, so that here a confirmatory experiment is to hand that in fused caustic soda ions are already in existence, and that no energy is required to disrupt the molecule of sodium hydrate. A discussion ensued on the author's claim to have discovered a difference in the mode of electrical conduction in fused sodium hydrate as compared with an aqueous solution of the same substance, the tone of which was adverse to the claim. H. H. Ho.

1306. *Vibrating-Flame Rectifier for High-Tension Currents.* **J. J. Dowling** and **J. T. Harris.** (Roy. Dublin Soc., Proc. 16. pp. 171–174, Feb., 1921.)—If a flame, placed between the electrodes of a spark-gap in a circuit, be made to vibrate in synchronism with the pulsations of e.m.f., a supply of ions in the gap is made available when the e.m.f. is directed in one sense through the circuit, while there are practically none available to carry the reverse component of current. The flame vibrations must so occur that the flame rises and falls once while the e.m.f. makes one complete alternation. The vibrations of the flame are produced by a Koenig's manometric capsule, the membrane of which is either a thin iron plate or an india-rubber diaphragm, to the centre of which is attached a small piece of iron. Mounted close to this is an electromagnet with two independent windings; through one winding the full primary current of the high-tension transformer passes, and the other carries a direct current from a storage battery. The magnetising effect of the direct current is almost equal to the max. value of that due to the a.c. winding, so that the disc is attracted once only for a complete oscillation of the high-tension e.m.f. In this way flames are obtained oscillating between

1 cm. and 10 cm. in height, the height when the diaphragm is still being 9 cm. The authors describe experiments to test the apparatus by rectifying an a.c. supply transformed by a coil up to 6000 volts. T. H.

ALTERNATING CURRENTS AND MAGNETISM.

1307. *The Homologues of a Permanent Magnet.* **H. Chipart.** (Comptes Rendus, 172. pp. 960–962, April 18, 1921.)—Having defined, in a previous paper [see Abs. 1158 (1921)], the homologue of a magnet immersed in an infinite magnetic liquid of permeability μ, the homologues of a permanent magnet of arbitrary form, uniform magnetisation, and any orientation, are studied, and the following conclusions are stated. The moment M_1 of the homologue is a symmetrical, linear, vectorial function of the moment M of the given magnet. The scalar product MM_1 is equal to 2ϕ, where ϕ is a quadratic function of the rectangular components of M. The quadratic function $\phi(x, y, z) - 1 = 0$ represents an ellipsoid when the liquid is paramagnetic; this is also the case for diamagnetic liquids. G. E. A.

1308. *Magnetisation Curves and Hysteresis Cycles.* **H. Lorenz.** (Zeits. techn. Physik, 2. 3. pp. 63–71, 1921.)—Working from the same equations as Kelen [see Abs. 939 (1921)] for the equilibrium of a magnetic element in an iron bar, an equation is obtained which expresses the magnetisation curve from the neutral state; equations are also derived which represent symmetrical and asymmetrical hysteresis curves, and an expression is given similar in form to Steinmetz's, for the area of the cycle, which measures the hysteresis loss for weak magnetisations. G. E. A.

1309. *Comparison of Magnetic Declination Changes at British Observatories.* **C. Chree.** (Roy. Soc., Proc. 98. pp. 411–414, March 3, 1921.) —Diurnal inequalities of declination at Kew on quiet days have shown great similarity to those of Falmouth and Eskdalemuir, but the regular diurnal inequality derivable from the combination of disturbed days differs from that of quiet days; also the curves have pointed to Kew being less disturbed than Eskdalemuir. A further investigation, in which the diurnal inequalities at Kew and Eskdalemuir have been compared for days of different magnetic character, now shows that the difference increases with the amount of disturbance, and is similar in type to the difference between the diurnal inequalities of quiet and disturbed days at Kew. Comparing the mean daily and mean hourly values at the two places—after applying, as a constant correction to the Kew values, the mean difference of declination between the two places—it is found that the mean for the average day of the period considered, when so corrected, differs from the observed Eskdalemuir value by about 0·5′. For the hourly values, considering the difference between the Kew and Eskdalemuir means for each hour of the day, the range in this quantity is found to depend on the degree of disturbance, the mean ranges being 2·1′ for days of character 0, 3·2′ for character 1, and 7·6′ for character 2. On one day of character 2 the range amounted to 32·9′.

Oscillation amplitudes have previously been compared for 1908–9 for Eskdalemuir (E), Stonyhurst (S), Falmouth (F), and Kew (K), with the result: E/K = 2·14; S/K = 1·68; F/K = 1·14. A further comparison for a period of 1919 shows E/K = 1·54 and S/K = 1·01, while

a comparison of Kew and Falmouth for period 1908–13 shows a tendency for F/K to decrease towards the end of the period. It is concluded that while the ratio of oscillation amplitudes at two stations may be fairly constant over a period of months, this does not hold for longer intervals.
M. A. G.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1310. *Can the Constancy of Radiation of Tubes or Needles of Radium be relied upon?* **T. Nogier.** (Arch. d'Él. Médicale, 29. pp. 110–112, April, 1921.)—A general discussion as to whether a purchaser of radium for medical purposes can consider, owing to the extremely long period required for radium disintegration, the effects during a human lifetime as being constant. The author considers this constancy during six or seven years is illusory, in spite of certificates such as are given by the Curie laboratory. He states that owing to minute orifices in the lead case the radium can escape during sterilisation. However much hermetical sealing may be obtained in the first instance, any accidental injury to the envelope during operations, etc., leads to loss and also the internal bombardment of the envelope leads to modification of its molecular structure. The accumulation of the helium evolved is stated to raise the pressure and increase losses via minute orifices, and the author concludes that in practice the life, and therefore the medical properties, of a tube of radium cannot be considered as constant. B. J. L.

1311. *Radiotherapy of Deep Tissues and its Realisation by a French Apparatus.* (Arch. d'Él Médicale, 29. pp. 69–82, March, 1921.)—This paper deals with radiotherapy apparatus of the firm of Gaiffe-Gallot and Pilon. A general review of the requirements of radiotherapy as differentiated from radiography is given; the physical aspects are then dealt with. The dissipation of the X-ray energy is due partly to dispersion and partly to selective absorption with change to another wavelength, this dissipation being analogous to light-energy dispersion and absorption. Of these two modes of energy-change, the first is stated to be constant, while the second varies proportionally to the cube of the wave-length. The subject of X-ray therapy is then dealt with on general lines, figures being given of the absorption due to screens of Al, Cu, Ag, and Sn.

Apparatus for Deep Radiotherapy.—The apparatus forming the subject of this paper is then illustrated and described. Briefly it consists of a Coolidge tube immersed in oil in a lead container of 6 mm. thickness, which is mounted upon a transporter arrangement so that it can be freely moved above the patient, who is subject to the radiation via an aperture in the bottom of the container. The advantages claimed for this apparatus are: high power, elevated intensity, non-interruption by heating, protection from the X-rays owing to the lead case, electrical protection from the high-tension supply of both patient and operator; the tube is, further, independent of humidity and dust, and there is inappreciable formation of ozone. B. J. L.

1312. *Action of the Lilienfeld X-ray Tube.* **A. Dauvillier.** (Comptes Rendus, 172. pp. 1033–1036, April, 25 1921.)—Describes the nature and action of the Lilienfeld tube, and results obtained with it. B. J. L.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1313. *Mercury Distillation Apparatus.* **A. Elicabe.** (Phys. Zeits. 22. pp. 120–121, Feb. 15, 1921.)—A description is given of an improved form of mercury distillation apparatus, which avoids the defects of the well-known Weinhold's apparatus (see J. Frick, Physikal. Technik. 7th ed. [Publ. by O. Lehmann, Brunswick, 1904] Band. 1. p. 582). In the new apparatus the mercury is electrically heated and a continuous supply of clear distilled mercury obtained without attention being given to the supply of dirty mercury. The latter is sucked from an open vessel as required. A. B. W.

1314. *Atomic Volume of Isotopes : Collected Data on Lead.* **F. Soddy.** (Nature, 107. pp. 41–42, March 10, 1921.)—The author gives the following collected data relating to the atomic volumes of different isotopes of lead :—

Variety of Lead.	Atomic Weight.	Density at 20°.	Atomic Volume.	Difference from Mean
Ordinary	207·199	11·3465	18·2619	+ 0·0009
Ceylon thorite	207·694	11·3760	18·2572	— 0·0038
	207·77		18·2639	+ 0·0029
		Mean	18·2610	
Ordinary	207·20	11·337	18·2765	— 0·0026
Australian uranium ore	206·34	11·288	18·2796	+ 0·0005
Norwegian clevite	206·085	11·273	18·2813	+ 0.0022
		Mean	18·2791	

The differences in the atomic volume are thus exceedingly small, and, moreover, they are not systematic. Rejecting the single determination of the atomic weight of thorite lead, it appears that ordinary lead with the intermediate atomic weight has an atomic volume slightly below that of the others. It seems safe to conclude that the atomic volumes cannot differ by so much as 3 parts in 10,000 and the atomic diameters by so much as 1 part in 10,000. A. B. W.

1315. *Sorption of Iodine by Carbon.* **J. B. Firth.** (Faraday Soc., Trans. 16. pp. 434–452, Feb., 1921.)—Iodine is dissolved in benzene (solubility 103·9 gm. per litre at 15° C.) or chloroform (36·2 gm.) and absorbed by lamp-black, sugar carbon, blood charcoal, animal charcoal, and coconut charcoal, both from the fruit and the shell, to study the influence of time (up to five years), size of particles, and previous treatment; most of the experiments are made at 25°. The paper is largely tabular. There is a rapid surface condensation (adsorption) followed by a slow diffusion into the interior (absorption). The former is mostly instantaneous and is complete in a few hours ; the latter may continue for years.

The rate of sorption is influenced by the natures of both the solvent and the sorbing solid. In blood charcoal the adsorption is very high; in coconut charcoal absorption is the predominating factor. The concentration of the dissolved iodine decreases to a minimum, and then remains almost constant; the initial adsorption is the greater, the smaller the carbon particles. Blood charcoal in chloroform sorbs 90 % of the total iodine, coconut (fruit) charcoal less than 3 %; the time taken to reach the concentration minimum amounts to 6 days in the former case (6 or 8 gm. of carbon per cm.^{3} of solution) and 5 years in the latter; in sugar carbon the minimum was not reached after 5 years. Fine powdering much increases the rate of sorption of coconut carbon; the relative amounts of adsorption and absorption depend to some extent on the size of the particles, and absorption may only cease to be a factor when the carbon particles approach molecular dimensions. The presence of water in the carbon lowers the adsorption capacity, especially in lamp-black. H. B.

1316. *Devitrification of Glass; a Surface Phenomenon; Repair of Crystallised Glass Apparatus.* **A. F. O. Germann.** (Am. Chem. Soc., J. 43. pp. 11–14, Jan., 1921. Chem. News, 122. pp. 124–125, March 18, 1921.)—In the devitrification of glass the silica which separates forms an infusible coating over the surface of the glass, and may under certain conditions dissolve in the underlying silicate, so that the surface clears up, whilst under other conditions it yields calcium silicate fusing with difficulty, in which case well-defined crystal surfaces may appear. According to the older hypothesis, this phenomenon is due to slow volatilisation of sodium oxide from glass near its softening temperature, and a common practice has been to reintroduce the lost alkali; this is, however, always difficult. It is found that the tendency to devitrify may be removed by rinsing the parts of the glass to be fused with dilute hydrofluoric acid; this treatment renders possible the repair of old apparatus. T. H. P.

1317. *The Fusion of Carbon.* **E. Ryschkewitsch.** (Zeits. Elektrochem. 27. pp. 57–64, Feb. 1, 1921.)—Indications of fused electrodes having been observed in the Kropfmühl graphite works, the author built up there a box frame, 7 by 7 cm., of graphite plates and closed the open front and back of the frame by cylindrical carbon rods, 10 cm. in diameter, cut square at the ends to fit the openings of the box which was charged with scaly graphite. Heating by currents of 560 amps. at 30 volts for up to 12 hours, he sometimes found the electrode ends, after a few hours, converted into a soft graphite; coalescing drops had apparently run down the faces. The greatest heat had probably been developed at the contact between the electrode ends and the scaly graphite. The fused carbon for graphite contained up to 99·9 % C; nothing is said as to what became of the 8 % of mineral matter in the electrode carbon. A supported rod, not packed with graphite, showed some soft graphite under the irregularly corroded surface. Photographs of the specimens are reproduced, and the literature on the subject is discussed. The author agrees with Lummer that high current-density is not favourable to fusion; he himself worked with 5 to 10 amps/cm.^{2} on the average. H. B.

1318. *Determining Factors in Volatility.* **O. Ruff.** (Deutsch. Chem. Gesell., Ber. 52. i. pp. 1223–1238, 1919.)—Compounds which are volatile at or below temperatures of 100° C. contain one of the elements F, H (as a positive element), Cl, O, or N. The influence of the mass of the element is, in general, negligible in the case of the central atom, UF_6, for instance, being as volatile as BF_3, but all readily volatile compounds possess light atoms in the periphery of the molecule. The atomic volume of the element has no apparent influence, and in substances of two elements the number of atoms in the molecule has only a minor effect on the volatility.

The most important determining factor in volatility is the occurrence of a minimum number of electrons, or negative charges, in the shells of the atoms as measured by the number of electrons required to give complete octets *less* the number of co-valencies or electrons shared by atoms. The more volatile compounds are thus those in which the octets of the outer rings of electrons are completed by the sharing of pairs of electrons rather than by ionic interchanges between atoms.

Residual valency of the central atom, as in the case of unsaturated metallic compounds, diminishes the volatility probably through giving rise to molecular association. Molecular symmetry is also an important factor in determining volatility, the freedom of movement of gaseous molecules being conditioned by the symmetrical distribution of mass and energy. A weak external field is obtained with molecules in which the central positive nucleus of the atom is neutralised by a symmetrical distribution of the surrounding electrons. In this case, as with the compounds CF_4, CH_4, SF_6, SiF_4, substances of low boiling-points result. With a non-symmetrical distribution of electrons, the positively-charged nucleus is exposed in certain directions so that a strong external field results and as in the case of SiO_2, UF_4, leads to a juxtaposition of, and adhesion between, molecules resulting in non-volatility. In order to approach static symmetry, the central atom must be surrounded by at least 4 atoms and the larger the number of atoms, the higher the degree of symmetry. Dynamic symmetry may be obtained by means of a spherical rotation of the whole molecule or a circular rotation of the periphery Movements of atoms and molecules under the influence of heat can thus lead to a symmetrical field of force as obtains with the gases H, F, Cl, O, and NO, such as is given in the case of the H_2 molecule by the Bohr model. The heat of vaporisation of a substance can thus be regarded as a measure of the work necessary to impart the necessary motion to bring the more or less unsymmetrical linking to a state of dynamic symmetry. J. N. P.

1319. *Atomic Forces.* **W. Kossel.** (Zeits. f. Physik, 1. 5. pp. 395–415, 1920.)—The recent work of Ruffs on volatility [see preceding Abs.] has led the present author to put forward the following considerations towards the classification of atomic forces. Ruff regards the volatility of quite simple inorganic compounds as a function of the position of the constituent elements in the periodic system. The comprehensive example of the fluorides is taken, viz. NaF, MgF_2, AlF_3, SiF_4, PF_5, SF_6. The volatility of these bodies shows a very striking gradation, the first members being fusible with difficulty and the boiling-points unknown, while from SiF_4 onwards they are gases which condense at −90°, −75°, and −56° respectively. This transition in behaviour is general for all periods and abrupt, so that a line of separation between fluorides of difficult and ready volatility can be drawn in the periodic system to the right of BeF_2, AlF_3, TiF_4, SnF_4, and BiF_3. The phenomenon betokens a sudden rapid decrease of the forces which unite the separate molecules together in the solid body. In the present paper it is shown after a very comprehensive discussion, that a change must hereby ensue in the mechanism of the union [see also Abs. 641 (1916)]. At the extreme point the nature of the intermolecular union must have an entirely different character when Werner's co-ordination number is attained, although actually the change takes place earlier. A scheme with illustrative diagrams is put forward to represent this phenomenon. These considerations are next extended to a large number of compounds of the higher halides, whose atomic volumes are greater. Following this comes a discussion of the alkali polyhalides such as KI_3, RbI_3, CsI_3, whose existence appears to be due to this developed conception of force distribution. The structure of homopolar double molecules next receives attention. The remarkable rise in the boiling- and melting-points for homopolar unions is not limited to the halogens, and Lothar Meyer's work in this connection is discussed. The inactive elements He, Ne, Ar, Kr, X, Em, then receive detailed consideration, and strong evidence is submitted for the intermolecular forces in this series being consubstantial. The author summarises his conclusions in the following classification:—Class I.—Pure heteropolar substances subdivided into those with an ionic lattice such as NaCl, and those possessing a lattice of positive ions with mobile electrons such as Na. The forces are electrostatic and the volatility small. Class II.—Pure homopolar substances subdivided into those possessing a pure cohesion lattice such as argon, and those with a homopolar molecular lattice such as Cl_2. Homopolar cohesion forces serve for the molecular union, while the volatility is high. Class III.—This includes mixed heteropolar molecules in homopolar union such as $SiCl_4$. In the molecules the forces are electrostatic, between the molecules homopolar cohesion forces operate; the volatility is high. H. H. Ho.

1320. *A Sensitive Method of Thermal Analysis.* **A. Perrier** and **F. Wolfers.** (Arch. des Sciences, 2. pp. 372–381, Sept.–Oct., 1920.)—Rev. de Mét. 18. pp. 111–116, Feb., 1921.)—The differential method previously described [Abs. 1170 (1918)] is applied to the heating curves of quartz, iron, and nickel. The change from α–β quartz is well shown at 615° C. on heating and 580° C. on cooling. In iron, in addition to the usual points is found a large one about 1130° C. Two kinks occur in nickel, at 480° C. and 880° C. F. C. T.

1321. *Use of Very Slow Coolings in the Micrographic Study of Alloys; Tungsten Steels.* **A. Portevin.** (Comptes Rendus, 172. pp. 964–967, April 18, 1921.)—The very great value of cooling metallic samples excessively slowly prior to their microscopical examination, in the investigation of equilibrium conditions, is emphasised. The constitution of tungsten steels containing 0·1 % to 0·4 % carbon and 5 % to 7·5 % tungsten has been studied in this way, the alloys being annealed at 1300° C. and then slowly cooled down to 200° C., the cooling lasting for 75 hours. Under these conditions the alloys consist of (1) a tungsten ferrite, (2) a tungsten carbide, (3) troostite, and (4) a newly discovered constituent said to be a complex of ferrite and iron tungstide. J. L. H.

1322. *Dilatometric Study of Transformations.* **P. Braesco.** (Ann. de Physique, 14. pp. 5–75, July–Aug., 1920.)—The author has studied allotropic and other transformations in silica and in a number of alloys by means of a slightly modified form of Chevenard's dilatometer. *Silica.*—He states that above 1600° C. cristobalite is the stable form, while below a temperature somewhere between 1300° C. and 1400° C. quartz is the equilibrium phase; between these two tridymite exists. All three forms are easily preserved at room temperatures (as is amorphous silica, which the author shows to be the same as vitreous silica) and each of them undergoes transformations at low temperatures, α quartz transforming into the β modification at 575° C. and α crystobalite into β crystobalite at about 230° C., while in the case of tridymite, the α variety transforms into the β at 110° C. and into the γ at 145° C. The dilatation of various clays was also investigated.

Alloys.—The author gives a resumé of present knowledge of the constitution of certain alloy systems and then describes results he has obtained by dilatometric observations. *Cu-Sb alloys.*—The dilatometer is stated to prove the existence of the compound Cu_3Sb_3 thus confirming Baykoff's and Carpenter's work and disproving that of Kurnakoff and his colleagues. *Cu-Zn alloys.*—The 470° C. transformation in β shows but slightly on the dilatometer curves, while in the case of an alloy containing 75 % Zn, an allotropic transformation in the δ phase at about 540° C. can be seen. *Cu-Sn alloys.*—Experiments have been carried out on alloys containing up to 32 % Sn. The $\beta = \alpha + \delta$ transformation at 500° C. and the change in $CuSn_3$ at 590°C. are well shown by the dilatometer. *Cu-Al alloys.*—The decomposition of β is also shown on alloys between 9 % and 15 %Al.

J. L. H.

1323. *Silicon-Iron Alloys.* **A. T. Lowzow.** (Chem. and Met. Eng. 24. pp. 481–484, March 16, 1921. Translated by **O. A. Hougen** from Tidskrift för Kemi, 16. No. 1. 1919.)—In their diagram of state of 1905 Guertler and Tammann reduced the probable number of Fe-Si compounds to Fe_2Si and FeSi: their thermal investigation was conducted with small charges. The author received from metallurgical works 21 specimens of ferrosilicon—weights not stated—ranging in Si from 49·1 up to 93·4 %, and concluded, mainly from microscopical examination and from the work of others, that the following compounds exist (the first is doubtful): Fe_3Si_2 (?), Fe_2Si, Fe_3Si_2, FeSi, $FeSi_2$, $FeSi_3$. The research concerns in particular the eutectic (FeSi + Si), and the formation of $FeSi_2$. Accepting these conclusions, Hougen corrects and supplements the Guertler-Tammann diagram. Lowzow also determined the specific gravity of the various alloys (powdered, as they are full of gas and air spaces) with the aid of a pyknometer in carbon tetrachloride. The densities (Si itself 2·5) of the alloys, from the richest in Si down, range from 2·542 up to 4·630; between 70 and 78 % Si the decrease in density with increasing Si is regular, so that, within that range particularly, the silicon percentage could much more quickly be estimated from the specific gravity than from the chemical analysis. H. B.

1324. *State of Carbide in Carbon Steels Quenched and Tempered.* **S. Saitô.** (Tôhoku Univ., Sci. Reports, 9. pp. 281–287, Aug., 1920. 38th Report of the Iron and Steel Research Inst.)—From the point of view of the space-lattice of the quenched steel, carbon in solution as such, or as cementite, is identical. On tempering a quenched steel up to 300° C. cementite is set free, which is decomposed into iron and carbon. In hypereutectoid steels a similar decomposition of carbide occurs above

Ac1. An equilibrium condition is attained with carbon both free and combined. The foregoing results are obtained from magnetometer measurements, and changes in the structures, other than those due to the cementite changes A_0, are completely neglected. [See Abs. 1178 (1917).] F. C. T.

1325. *Cause of the Instability of Nickel Steel.* **C. E. Guillaume.** (Comptes Rendus, 171. pp. 1039–1041, Nov. 29, 1920.)—The secular change in dimensions of invars is shown to depend on the carbon content becoming nil in the carbonless alloy. Since such alloys cannot be readily produced, it is suggested that Cr or W be added, whose affinity for carbon is greater than that of Fe; and in the case of Cr such a procedure reduced the secular alteration to $\frac{1}{10}$. It is necessary to add a small excess of Cr, which slightly raises the dilatation. F. C. T.

1326. *The Ar3 Point in Steels and Martensite.* **P. Dejean.** (Comptes Rendus, 171. pp. 791–794, Oct. 26, 1920.)—[See Abs. 167 (1921) and 1379 (1917)].—In steels with increasing quantities of Mn the Ar3 point is progressively lowered, the more so as the C content is increased; while the Ar1 point is lowered much less, the lowering being reduced as the C is raised. Thus the Ar3 point may be below Ar1. Three sets of results may thus arise: the precipitation of the carbide may cause the allotropic change to occur; the precipitation of carbide may be incomplete at Ar1, and complete itself at Ar3, thus doubling the point; or the carbide may remain in solution, the Ar3 point alone being found. This results in martensite: a solution of carbide in α iron. In the nickel steel similar effects are found. F. C. T.

1327. *Formation of Spheroidal Cementite.* **K. Honda** and **S. Saitô.** (Tôhoku Univ., Sci. Reports, 9. pp. 311–317, Aug., 1920. 40th Report of the Iron and Steel Research Inst.)—The conclusions reached are: A quenched steel tempered below the Ac1 point shows a spheroidal sorbitic structure. In a hypereutectoid steel quenched between the cementite line and the Ar point the undissolved cementite is spheroidal. A pearlitic steel with laminated structure is spheroidalised by reheating to the Ac1 point or just above, but not below Ac1. Granular pearlite spheroidises below the Ac1 point if sufficient time is allowed. The temperature interval above Ac1, in which spheroidalisation occurs, increases from 20 deg. C. for a 0·3 % carbon steel to 100 deg. C. for a 1·9 % carbon steel. F. C. T.

1328. *Relation of the High-Temperature Treatment of High-Speed Steel to Secondary Hardening and Red-hardness; Influence on Magnetic Properties.* **H. Scott.** (Bureau of Standards, Bull. 16. pp. 521–536 [Sci. Papers, No. 395], 1920.)—The work was carried out on a steel of the following percentage composition: C, 0·77; W, 17·8; Cr, 3·5; V, 0·74. The best magnetic results were obtained after quenching in oil, from 1050° C., when $H_c = 70$, $B_{rem.} = 6300$, and $B_{max.} = 9100$. By subsequent immersion in liquid air $B_{rem.}$ and $B_{max.}$ rose to 6700 and 9300 respectively. The Brinell and scleroscope hardness attained the max. value for steel quenched about 1070° C., and the highest density when quenched from 1230° C. The steels quenched in the region of 1050° C. tended to crack badly. Steels quenched from 1220° and 1300° C. showed a distinct increase in hardness on being tempered from 400° to 650° C., which was not shown where the quench temperature was below 1100° C. This effect was reproduced in the magnetic tests, and when quenched from 1290° C. and tempered at 600°–650° $H_c = 55$ and $B_{\text{rem.}} = 9000$. These tempering phenomena are due to the change from austenite to martensite. F. C. T.

1329. *The Solution Theory of Steel; Influence of Changes in Carbide Concentration on the Resistivity.* **E. D. Campbell.** (Faraday Soc., Trans. 15. pp. 138–147; Disc., 148–149, June, 1920.)—A series of steels were examined in the quenched condition before and after decarburisation in hydrogen. The resistivities do not agree well with Benedicks' formula, showing that the several elements were not all present in solution. F. C. T.

1330. *Cause of Piping in Aluminium Ingots.* **J. D. Edwards** and **H. T. Gammon.** (Chem. and Met. Eng. 24. pp. 338–340, Feb. 23, 1921.)—A method of determining the piping effect in metals is described and the results of measurements on a series of Cu-Al alloys are given. It is shown that although the solidification shrinkage of a metal is responsible for the formation of the pipe, it is not necessarily proportional to it. The volume of pipe formed in any given alloy is a complex function of the following factors: (1) Contraction during solidification; (2) rate of solidification during the freezing interval; (3) temperature range of the freezing interval; (4) size and form of the mould, and probably some other conditions. It is, however, impossible to describe piping as a definite property of a metal. In the case of pure Al the volume of the pipe is very nearly equal to the contraction upon freezing, due to the fact that the shell first formed is quite rigid, and the contraction during freezing necessarily appears in the form of a central cavity. In the case of alloys, however, the solid which separates first, consists of a network of crystals more or less interpenetrated by liquid. This may be quite plastic, and the shell first formed is not so rigid as that formed in the case of a pure metal. As a result of this, the partly frozen metal within the mould behaves as if still liquid for a considerable interval of temperature below the commencement of freezing, and the volume of the pipe is less than in the case of a pure metal. C. O. B.

1331. *Density of Aluminium from 20° to 1000° C.* **J. D. Edwards** and **T. A. Moormann.** (Chem. and Met. Eng. 24. pp. 61–64, Jan. 12, 1921.)—The results of the determination of the density of Al at various temperatures are given. The use of a silica sinker weighted with iron or nickel was tried, but was abandoned owing to the attack of the silica by Al, especially at temperatures above 700°. Particulars are given of a densimeter devised by Frary and Edwards, which consists of filling a known volume with the metal at the desired temperature and weighing the metal. The effect of physical treatment and annealing on the density of aluminium samples varying from 98·25 to 99·75 % Al is shown, and from the results it is calculated that the density of pure Al is very nearly 2·7. The working of Al is shown to increase its density by the elimination of voids, but a point may be reached at which further deformation results in a decrease in density and the annealing of such metal again produces an increase in density. This latter effect is best explained by the production of amorphous metal during working, which modification has a lower density than crystalline Al. The results of density determinations of different samples of Al are given; they average about 2·37 at the melting-point, and 2·29 at 1000° C. The density of liquid Al (99·75 per cent.) may be expressed by the following equation: $D_t = 2{\cdot}382 - 0{\cdot}000272(t - 658)$. From the data obtained, it has been possible to derive results of importance on solid and solidification shrinkage. The solid shrinkage of the pattern maker is the linear contraction in cooling from solid metal at 658° to room temperature: as calculated from the expansion formula this amounts to 0·22 in. per ft.; tests made on cast bars gave 0·21. The solidification shrinkage is the change in volume of the metal in cooling from a liquid at the freezing-point to a solid at the melting-point, and in the case of Al is about 6·6 %. In the casting of the metal, it must be poured at a higher temperature than the solidification point, and the total shrinkage will be greater. The liquid shrinkage is the contraction of the liquid in cooling to the freezing-point, and varies with the temperature interval through which the metal cools. A table is given showing the total shrinkage from various temperatures. C. O. B.

1332. *Mechanism of Solidification of a Copper-Aluminium Alloy.* **J. D. Edwards.** (Chem. and Met. Eng. 24. pp. 217–220, Feb. 2, 1921.) —The results of density determinations of a series of Cu-Al alloys containing 8, 30, and 60 % copper at 20°, 700°, 800°, 900°, and 1000° C. are given. By the employment of the expansion data for the solid metal, and by several methods of interpolation the density of any alloy containing between 0 and 60 % Cu can be estimated with a fair degree of accuracy between 0° and 1000° C. These data taken together with the thermal equilibrium diagram for the system have furnished some valuable information regarding the volume changes occurring in the alloys during freezing; they are discussed with particular reference to the 8 % copper alloy. Although there is no direct relation between density and composition, the specific volume of the Cu-Al alloys is very nearly a linear function of the composition. In the case of the 8 % copper alloy, the density in the cast condition is about 2·86. Freezing of this alloy begins at 636° and is completed at 540°. The first crystals formed are heavier than the liquid, and tend to sink; they have, however, less Cu than the liquid in which the copper concentrates, so that at 630° the two become equal in density, when approximately 25 % of the liquid has crystallised. At all temperatures lower than 630° the crystals are lighter than the liquid and tend to float. These differences of density between crystals and liquid may be directly a cause of porosity in castings, and have a direct effect on piping, segregation, etc. [See preceding Abs.] C. O. B.

1333. *Alloys of Gold and Silicon.* **C. di Capua.** (Accad. Lincei, Atti. 29. i. pp. 111–114, Feb. 1, 1920.)—The author has studied the diagram of state of the system gold–silicon, gold of 0·999 purity and silicon containing 4–5 % of impurity, mostly iron, being used, and fusion and cooling of the mixtures carried out in a rapid current of hydrogen. Owing to the low thermal conductivity of Si, the duration of the arrests of the cooling was very irregular, and yielded no information. The cooling results show that Au and Si are miscible in all proportions in the liquid condition, that they form no compounds, and that they are non-miscible in the solid state, at any rate within the limits of the experimental accuracy attained. The eutectic alloy melts at 370°. With the alloy containing 85 per cent. of silicon, no retardation corresponding with the solidification of the eutectic is observable, but microscopic examination reveals crystals of gold dispersed throughout the mass; the formation of mixed crystals at this concentration is, therefore, excluded. Almost all the alloys rich in Si exhibit at the surface a golden-yellow globule, which is sharply detached from the greyish-blue, metallic block, and contains a greater proportion of gold than the mixture from which it is formed. A similar globule has formerly been observed with Si-Ag alloys and with Si-Al alloys, and its formation is certainly due to the fact that Si solidifies with increase of volume. Hence, during the solidification, the part which solidifies last, namely the eutectic, is forced upwards and forms the globule. The melting-point of gold is lowered by about 800 deg. by 6–7 % of silicon.

Microscopic examination of the alloys fully confirms the results of the thermal analysis. T. H. P.

1334. *Elementary Quantity of Energy Acting during Solution.* **R. Audubert.** (Comptes Rendus, 172. pp. 676–678, March 14, 1921.)—The marked analogies between vaporisation and dissolution would indicate that these two phenomena should obey the same laws, so that for the dissolved state a law equivalent to the Pictet-Trouton law may be assumed. Thus, if ρ represents the molecular latent heat of solution and T the temperature which corresponds, for a state of saturation, with an osmotic pressure of 1 atmo., the ratio $\rho : T$ should be constant. Direct verification of this result is not possible, but extrapolation from the known results for a number of salts gives, for a pressure of 1 atmo., the value 30–32 for ρ/T. Division by Avogadro's number of the limiting value of ρ/T expressed in ergs gives the elementary quantity of energy necessary to cause the dissolution of a molecule, which is thus found to be 18×10^{-16} T erg. This is, in fact, the value obtained for the energy of vaporisation or dissociation of solids. [Cf. Abs. 1284 (1921).] T. H. P.

1335. *On the Kinetic Theory of Osmotic Pressure.* **K. F. Herzfeld.** (Ann. d. Physik, 64. 7. pp. 646–660, April 19, 1921.)—Although the kinetic theory of osmotic pressure has been rigidly treated by Lorentz and Jäger, the present author deems another discussion opportune, in view of the phenomena appearing more complex than described by the above authors. Two problems have to be solved on the kinetic theory—namely: (1) The magnitude of the osmotic pressure, $\pi = RT/V$, which exists when a solution is in equilibrium with its solvent through a semi-permeable membrane. (2) The nature of the mechanism which forces solvent into the solution when both stand under equal pressures. The first problem has been exhaustively treated by Jäger, so that the present paper considers the latter. Section 1 deals with the pressure in a pure liquid. Section 2 examines the osmotic pressure in a solvent, which exerts no attraction upon the dissolved substance, and section 3, where such attraction exists. Section 4 investigates the internal pressure. It is shown that the presence of attractive forces does not alter the osmotic pressure, since these forces only transfer a part of the effect to the solvent, which in their absence would be exerted directly by the dissolved substance on the surface. With sufficiently strong attractive forces the kinetic pressure of the dissolved substance acts upon the capillary layer of the solvent, instead of upon the free surface. This latter is the pressure which displaces the surface, and so is the cause of the solvent's passage through a semi-permeable membrane. Attractive forces produce an increase in the internal pressure of a solution, yet Tammann's data do not agree with the results expected from the heats of hydration. H. H. Ho.

1336. *Gibbs' Phase Law.* **H. le Chatelier.** (Comptes Rendus, 171. pp. 1033–1038, Nov. 29, 1920.)—The author, after summarising Gibbs' proof of the phase laws, enumerates the various pitfalls which have led to errors in its application, and have given rise to unfounded criticisms of its accuracy. The law is expressed by the equation $V + v = m - q + p - r$, where V is the number of variables at disposal, v that of the variables determined by the initial conditions of the experiment, while r, q, p, m, represent, respectively, the numbers of co-existent phases, reversible chemical reactions, energy tensions (*e.g.*, of pressure, temperature, etc.), and distinct constituents of the r coexistent phases. There is no theoretical difficulty in determining r, but in constant-pressure systems the disappearance of the gaseous phase is often forgotten, and when precipitates are formed it is frequently impossible to distinguish experimentally the different phases mixed together. Indeed, the phase law is often utilised for determining the r by aid of an experimental determination of V. In most cases $p = 2$ (pressure and temperature). But in the case of a galvanic couple $p = 3$, as is also the case where surface tension comes into play through the fine subdivision of a precipitate. Again, p is increased from 2 to 3 when there is a difference of pressure between two phases, *e.g.*, in the névé of snow. On the other hand, the law is inapplicable when within the same phase there are energy variations from point to point, variations of pressure or temperature; or, again, precipitates on porous bodies of various diameters, as in the case of colloids. In the case of reversible reactions, only those must be taken into account which actually take place. For example, $q = 1$ in case of a mixture of O, H, and H_2O at 2000° C., a temperature at which the dissociation of H_2O becomes reversible. The disagreement of Dubreuil's enunciation of the law with that of Gibbs, to which Raveau has recently called attention, arises simply from the fact that the former considers only systems in which the possible reactions actually occur. An error to be avoided is that of counting as distinct reactions, groups of reactions in which one or more is a consequence of the others. In general, it is necessary, before applying the phase law, to determine by chemical examination what are the substances actually present. But changes which leave $m - q$ unchanged may be left out of account. For example, in studying the solubility of sodium sulphate, we do not know whether or not the two hydrates and the anhydrous salt coexist in the solution, and yet the law is applicable, since the addition of a hydrate increases both m and q by unity, and therefore their difference is the same in either case. The most serious difficulties arise in ascertaining how far the experimental conditions may introduce supplementary relations between the quantities which determine the system, *i.e.*, in determining the true value of v, the detailed examination required for their determination is often neglected. The value of V is generally obtained by determining experimentally how many conditions must be fixed or phases added in order to arrive at an invariant system. The final verification is obtained by showing that change of volume brings about no change in composition or in the

V.2
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energy tensions of any of the phases present. The mistake is often made of making a volume, or other change, so small that the resulting change in composition or in pressure may be masked by the unavoidable experimental error. G. W. DE T.

1337. *Pressure Variation of the Equilibrium Constant in Dilute Solutions.* **A. M. Williams.** (Faraday Soc., Trans. 16. pp. 458–463, Feb., 1921.)—During the discussion of a paper by W. C. McC. Lewis on a simple method of deducing Planck's formula $\delta \log k/\delta p =$ volume shrinkage/RT [*ibid.*, 12. pp. 314–321, June, 1917] J. Rice had suggested another statement of the thermal cycle, questioning Planck's deduction. Mazzucchelli [Accad. Lincei, Atti. 28. ii. p. 47 (1919)] pointed to an apparent slip in the cycle of Rice. The author suggests that the discrepancy between the values of Planck and of Rice concerning the expression for the variation with pressure of the equilibrium constant rests solely upon a misinterpretation of the meaning of the symbols; Planck's proof is unimpeachable, but both Rice and Mazzucchelli did not interpret him correctly. The paper is purely mathematical, not experimental.—In the *discussion,* **A. W. Porter,** referring to his paper on equilibrium of homogeneous mixtures [Abs. 328 (1921)], agreed with the author as to the difficulties of interpreting the meaning of Planck's critics; he introduced the gas law and osmotic pressure, upon which Planck did not rely, the author objected. H. B.

1338. *Relationships between the Electrokinetic Potential Change and the Electric Phase-Limit Force.* **H. Freundlich** and **P. Rona.** (Preuss. Akad. Wiss. Berlin, Ber. 20. pp. 397–402, 1920.)—At the limiting surface of two phases, two p.d.'s exist, namely, the thermodynamic, ϵ (Nernst), and the electrokinetic, ζ. The electrokinetic p.d. at glass and water was observed by Helmholtz, whilst the thermodynamic p.d. for the same system was discovered by Haber and Klemensiewicz (Zeits. phys. Chem. 67. p. 385, 1909], who explained its connection with Nernst's theory. The problem of the relationship between these two potential differences admits of experimental solution, and the following two series of experiments have been carried out: (1) Measurements of stream potentials in glass capillaries, and (2) Measurements of the phase limit force for the same glass according to Haber and Klemensiewicz's method. In complete agreement with other results [Kruyt, Abs. 1443 (1919)], it is found that the concentration of the electrolytes is of predominant importance, since with concentrations higher than about 1000 micromols, stream potential is no longer observed. The least active are salts with univalent kations, such as sodium and potassium chlorides and the like; far less active are salts with divalent kations, and also acids. Quite different relations are observed in the measurement of ϵ, and it is evident that ϵ and ζ are not identical. The electrokinetic double layer lies wholly in the liquid, and the p.d. ζ represents that part which falls in the displaceable liquid layers, whilst the thermodynamic p.d. ϵ is the whole p.d. existing between the interior of the first and that of the second phase. T. H. P.

1339. *Polarity of the Aluminium Cell.* II. **F. Streintz** and **F. Fiala.** (Phys. Zeits. 22. pp. 141–146, March 1, 1921.)—In experiments on gas generation from Al electrodes in diluted sulphuric acid hardly any gas was liberated on open circuit; the electrolysis by 14 storage cells gave very little oxygen at the anode, which collapsed in 24 hours; when the current was reversed before this collapse, the kathode (so far anode) gave the correct amount of hydrogen. In some further experiments several Al anodes were surrounded by one lead kathode. The relation between the current intensity in the anodic and kathodic directions, i_{12} and i_{21} [Abs. 912 (1920) and 185 (1921)] is $i_{12} = -a/2 + [(a/2)^2 + bi_{21}]^{1/2}$, where a and b are coefficients nearly of equal value increasing with the e.m.f. of the charging battery. The polarity $U = (i_{21} - i_{12})/i_{21}$ increases with the charging potential V in such a way that UV becomes constant, starting from a certain V; that value of V is now found to be much below 150 volts, but cannot definitely be fixed. The U depends only upon the current density (increasing with the density), not upon the V, provided the density is not high; this was observed by Zenneck; a valve effect is only obtained at high current-density. In this respect, then, the analogy between the aluminium cell and the unipolar conductivity of crystal detectors breaks down, because the electrolytic effect depends upon the supply of anions per unit time, whilst in the crystal detector there is no supply of gas. The Al-anode potential seems to approach a maximum of 17·5 volts. H. B.

1340. *Counter E.M.F. of the Aluminium Rectifier; Tantalum Valve.* **A. Günther-Schulze.** (Phys. Zeits. 22. pp. 146–148, March 1, 1921.) —According to the author the valve action of the Al rectifier is due to the formation of a very thin layer of gas, of high resistance, and a thicker, porous layer of aluminium oxide, the pores of which are filled with electrolyte and with gas. The whole may be compared to a condenser; since, however, the capacity and resistance of the formed anode are very high, the charge accumulated cannot disappear in a moment. Hence, Greene [Abs. 1643 (1914)] spoke of a polarisation, and Fitch [Abs. 347 (1917)] of a counter electromotive force and a double dielectric (gas layer and oxide layer). The author criticises these expressions, and especially the latter. The resistance of the oxide layer is very small by comparison with that of the gas layer, and the ohmic resistances are by no means constant. To prove this further he gives figures of experiments with tantalum electrodes in solutions of potassium nitrate and of borax; tantalum is preferable to aluminium, because the oxidation products formed are quite insoluble in the electrolyte. Since the effective layer is a gas layer, it was to be foreseen that the effective resistance e/i would depend upon the thickness of the layer and would rise rapidly as e (the charging potential) is lowered. H. B.

1341. *Contracted Condition of Electrolytic Metallic Deposits.* **[Miss] G. Aliverti.** (Accad. Lincei, Atti. 29. 1. pp. 453–457, June, 1920.)— The object of the investigations here described was to ascertain if the marked contraction usually exhibited by metals deposited electrolytically is due, to any appreciable extent, to thermal effects. The results obtained when solutions of nickel salts are electrolysed under different conditions show that this is not the case and that the contraction is due to a surface tension of the metallic layer dependent on the manner in which the metal is deposited. Confirmation is obtained of Storey's observation [Abs. 1163 (1909)] that the extent of the contraction diminishes as the temperature of the electrolytic bath rises, and it is found further that, when the deposition takes place from a solution containing strychnine, the metal is obtained first in an expanded state, the expansion subsequently undergoing conversion into a contraction of less degree than that observed with solutions of pure Ni salts. Increasing alkalinity of the solution electrolysed results in increasing contraction of the deposit, while the contraction diminishes if the solution is made acid and changes to expansion when 2 % by volume of sulphuric acid is present; in the latter case the expansion attains a constant value after the electrolysis has been continued for a certain time. Thus, the deposition of hydrogen simultaneously with the nickel appears to diminish the contraction of the deposit in proportion to the amount of hydrogen separating. T. H. P.

1342. *Linking of Electrons in Electrolytic Ions.* **A. Günther-Schulze.** (Zeits. f. Physik, 35. pp. 349–360, 1920.)—It is found that when an electrolytic cell with an anode of a valve metal, such as tantalum, is loaded with a constant current density, the e.m.f. taken by the cell continually increases, while an " active layer " forms on the metal until, at a maximum e.m.f. characteristic for each electrolyte, sparks occur in the active layer, these originating at the kathode of the active layer and hindering further rise of the e.m.f. Since the formation of kathode sparks depends on the ionisation of the kathode by ions, the ionising action of which depends on this maximal e.m.f., the latter constitutes a measure of the tenacity of union of the electrons in the kathode. The maximal e.m.f., which varies but little for metal-free anions, is depressed considerably if the anions contain metals such as Pt, Mn, Cr, or Fe, which thus effect a pronounced loosening of the linking of the electrons. The cause of this behaviour is to be sought in the fact that, for instance, the chromium in the CrO_4'' anion strongly attracts the electrons within the region of action of the oxygen, so that these assume an intermediate position between the field of the chromium and that of the oxygen from which they may be easily displaced; in the case of the sulphur in the SO_4'' anion, such attraction is only slight. It may be supposed that Cr attracts the electrons more strongly than S does on account of its smaller ionic volume.

When arranged in the order of the maximal e.m.f., the metals form a series practically the same as the electrochemical series, the attraction between metal and electron conditioning the maximal e.m.f. as well as the electrochemical behaviour.

A metal which weakens the linking of the electrons in an anion also weakens that in a molecule it enters as kation, but to a less extent. With increasing concentration of the anions, the stability of the linking of the electrons in anions increases by a fraction approximately constant for all anions, and a similar relation holds for molecules. T. H. P.

1343. *Electrolysis of Sodium Nitrite, using a Copper Anode.* **F. H. Jeffery.** (Faraday Soc., Trans. 16. pp. 453–457, Feb., 1921.)—The experiments were made as with silver anodes [see Abs. 754 (1921)], pure $NaNO_2$ (6·9, 13·8, or 27·6 gm. in 100 cm.^{3} of water) being electrolysed with a copper anode at 15° to 18° C. by currents of 0·16 or 0·35 amp. At the anode cupric anion $Cu(NO_2)_6$ is formed from the NO_2-ions and the copper; the cupric anion decomposes with water into the basic nitrite $Cu(NO_2)_2 . CuO$, and nitrous acid, the latter being slowly decomposed into nitric acid and nitric oxide (escaping). The presence of nitric acid at the anode must give rise to the formation of cupric ions; yet the 0·16 amp. did not deposit any copper on the kathode; the complex was formed, and the anode potential remained low. With 0·35 amp. copper was slowly deposited, and the increase of the current intensity increased the concentration of the NO_3 ions and the anode potential. The complex basic compound mentioned is slowly hydrolysed by water. H. B.

1344. *Theory of the Electrochemical Formation of Sodium Chlorate and Perchlorate.* **N. V. S. Knibbs** and **H. Palfreeman.** (Faraday Soc., Trans. 16. pp. 402–433, Feb., 1921.)—The paper describes experiments conducted on a large scale, but interrupted before completion; it is divided into three parts: I. Experimental, dealing with measurements of the conductivities of alkali chloride, chlorate, and perchlorate solutions and their mixtures, and with the velocity of the reaction in hypochlorite-chlorate; these experiments cover a wide range, but high accuracy is not claimed. II. Dealing with chlorate formation and its efficiency. III. Perchlorate. Sodium salts alone seem to have been studied. The last two parts are by Knibbs only. As regards II the efficiency losses are ascribed mainly to hypochlorite-ion discharge, and a formula is given for the efficiency in terms of hypochlorite-concentration, temperature, and other factors; current density does not enter. As regards III the theories of Oechsli and of Bennett and Mack (Am. Electrochem. Soc., Trans. 29. pp. 323–346, 1916) are discussed. The latter reject the discharge of chlorate-ion of the former; the author accepts this view of Oechsli, but interprets the subsequent reactions rather on the lines of the persulphate formation; some NaCl is formed by hydrogen reduction, especially at somewhat higher temperatures. H. B.

1345. *Copper Anodes in Caustic Potash.* **F. Jirsa.** (Zeits. Elektrochem. 27. pp. 30–34, Jan. 1, 1921.)—A copper anode in caustic potash becomes covered with Cu_2O, which soon passes into CuO, and a higher yellowish oxide, which E. Müller and Spitzer could not analyse. Kužma (Deutsch. Chem. Ges., Ber. 40. p. 3362, 1907), in separating copper from tellurium in caustic alkali, obtained a complex compound of a higher copper oxide (containing Te and K). The author having found that telluric acid temporarily depolarises a silver anode in caustic alkali during d.c. electrolysis [see preceding Abs.], found that this was not so with a copper anode; the telluric acid really stabilises Cu_2O_3. When a Cu/Cu_2O_3 electrode is prepared in caustic potash, the potential quickly falls to zero as soon as the polarising current is interrupted; in the presence of telluric acid, however, the potential remains constant. When the caustic is electrolysed with alternating current of frequency 49 cycles per sec., copper is oxidised and passes into solution as a monovalent metal, even when a hydrogen current is maintained through the solution. H. B.